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Report No. G-M-1-88

AD-A199 282

**INVESTIGATION OF THE FIRE SAFETY CHARACTERISTICS OF
PORTABLE TANKS --**

POLYETHYLENE TANKS CONTAINING FLAMMABLE LIQUIDS

BY

William H. McLain

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**U.S. COAST GUARD
MARINE TECHNICAL & HAZARDOUS MATERIALS DIVISION**

**Marine Fire and Safety Research Staff
Avery Point, Groton, CT 06340 - 6096**

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**Final Report
MARCH 1988**

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**United States Coast Guard
Office of Marine Safety, Security,
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Washington, DC 20593

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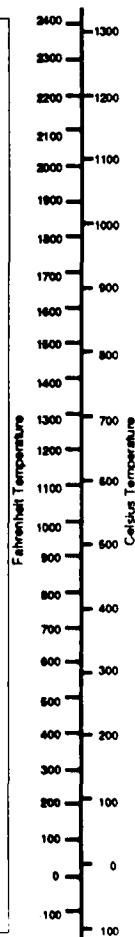
1. Report No. CG-M-1-88		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle INVESTIGATION OF THE FIRE SAFETY CHARACTERISTICS OF PORTABLE TANKS -POLYETHYLENE TANKS CONTAINING FLAMMABLE LIQUIDS				5. Report Date MARCH 1988	
				6. Performing Organization Code	
				8. Performing Organization Report No. CG-MFSRS-61	
7. Author(s) William H. McLain				10. Work Unit No. (TRAIS)	
9. Performing Organization Name and Address United States Coast Guard Marine Fire and Safety Research Staff Avery Point Groton, Connecticut 06340-6096				11. Contract or Grant No.	
				13. Type of Report and Period Covered FINAL	
				14. Sponsoring Agency Code	
12. Sponsoring Agency Name and Address Department of Transportation U.S. Coast Guard Marine Technical and Hazardous Materials Division Washington, D.C. 20593					
15. Supplementary Notes					
16. Abstract <p>➤ Full scale fire tests were conducted to determine the relative fire safety characteristics of portable polyethylene and steel intermediate bulk transport (IBC) containers containing flammable fuels. The results indicated that for both small and large exposure fires, the polyethylene tanks failed after a short exposure time presenting a major fire hazard caused by the release of large quantities of flammable fuels to the deck area. The steel tanks did not fail after either fire exposure but did, in some cases, develop large fire plumes at the vent release port. <i>Keywords:</i></p>					
17. Key Words polyethylene tanks, large fire exposure IBC tanks small fire exposure, steel tanks fire safety <i>fuel tanks. (SDU)</i>				18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) UNCLASSIFIED		20. SECURITY CLASSIF. (of this page) UNCLASSIFIED		21. No. of Pages	
				22. Price	

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Conversions to Metric Measures

When you know (symbol) Multiply by To find (symbol)

Length	
inches (in)	2.540
feet (ft)	30.48
feet (ft)	0.3048
Area	
square inches (in ²)	6.452
square feet (ft ²)	929.0
square feet (ft ²)	0.09290
Volume	
fluid ounces, US (fl oz)	29.57
gallons, US liquid (gal)	3.785
cubic feet (ft ³)	0.02832
cubic yards (yd ³)	0.7646
Mass (weight)	
ounces, avoirdupois (oz)	28.35
pounds (lb)	0.4536
Density	
pounds per cubic inch (lb/in ³)	27.68
pounds per cubic foot (lb/ft ³)	16.02
Pressure	
pounds per square inch (psi)	6895
pounds per square inch (psi)	0.0703
pounds per square inch (psi)	51.71
pounds per square inch (psi)	0.06895
inches of water (in H ₂ O) at 60°F	1.867
inches of water (in H ₂ O) at 60°F	248.9
inches of water (in H ₂ O) at 60°F	0.002489
inches of mercury (in Hg) at 32°F	3386
inches of mercury (in Hg) at 32°F	0.03386
Energy	
British thermal units (Btu)	1055
British thermal units (Btu)	0.2520
Thermal Conductance	
Btu / hr - ft ² - °F	0.0001356
Btu / hr - ft ² - °F	0.4882
Btu / hr - ft ² - °F	0.0005678
Heat Flow	
Btu / hr - ft ²	0.00007535
Btu / hr - ft ²	0.2712
Btu / hr - ft ²	0.0003154



Conversions from Metric Measures

When you know (symbol) Multiply by To find (symbol)

Length	
millimeters (mm)	0.03937
centimeters (cm)	0.3937
meters (m)	39.37
Meters (m)	3.281
Area	
square centimeters (cm ²)	0.1550
square centimeters (cm ²)	0.001076
square meters (m ²)	1550
square meters (m ²)	10.76
square meters (m ²)	1.196
Volume	
milliliters (ml)	0.03381
liters (l)	0.2642
liters (l)	0.03531
cubic centimeters (cm ³)	0.06102
cubic meters (m ³)	35.31
cubic meters (m ³)	1.308
Mass (weight)	
grams (g)	0.03527
grams (g)	0.002205
kilograms (kg)	2.205
Density	
grams per cubic centimeter (g/cm ³)	0.03613
kilograms per cubic meter (kg/m ³)	0.06243
Pressure	
pascals (Pa):	
newtons per sq. meter (N/m ²)	0.000145
bars (10 ⁵ N/m ²)	14.50
kilograms per square centimeter (kg/cm ²)	14.22
millimeters of mercury (mm Hg) at 0°C	0.01934
millimeters of mercury (mm Hg) at 0°C	0.5357
bars (10 ⁵ N/m ²)	401.8
pascals (Pa)	0.00402
pascals (Pa)	0.000295
bars (10 ⁵ N/m ²)	29.53
Energy	
Kilojoules	0.9478
Kilocalories	3.968
Thermal Conductance	
calories / sec - cm ² - °C	7373
watts / cm ² - °C	1761
Heat Flow	
calories / sec - cm ²	13270
Btu / hr - ft ²	

ACKNOWLEDGEMENTS

Mr. Frank Thompson was program manager for this project. Important contributions to the work were made by Mr. Robert O'Hagan and Ms. Denise Baird. The work could not have been accomplished without the assistance and editing of Ms. M.E. Mahoney. Finally appreciation is expressed for advice and technical support granted by Mr. N. Able of Poly Processing Co. with regard to polyethylene tankage.

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TABLE OF CONTENTS

	<u>Page</u>
1.0 BACKGROUND.....	1
1.1 INTRODUCTION.....	1
1.2 OBJECTIVES.....	1
1.3 TECHNICAL APPROACH.....	2
2.0 FACILITIES, MATERIALS, AND INSTRUMENTATION.....	3
2.1 FACILITIES.....	3
2.1.1 Fire Area	3
2.1.2 Fire Suppression Equipment	3
2.1.3 Environmental Protection Equipment	11
2.2 TEST MATERIALS	11
2.2.1 Exposure Fire Fuels and Tank Contents	11
2.2.2 Steel Tanks	14
2.2.3 Polyethylene Tanks	14
2.3 INSTRUMENTATION	14
2.3.1 Tank Weight-Loss Instrumentation	17
2.3.2 In-Tank Temperature Measurements	20
2.3.3 In-Tank Ullage Pressure Measurements	20
2.3.4 Video/Photographic Documentation	20
3.0 RESULTS	23
3.1 SMALL EXPOSURE FIRE TESTS	23
3.1.1 Polyethylene Tanks	23
3.1.2 Steel Tanks	23
3.2 LARGE EXPOSURE FIRE TESTS	28
3.2.1 Polyethylene Tanks.....	28
3.2.2 Steel Tanks.....	28
3.3 INTERACTIONS BETWEEN POLYETHYLENE TANKS.....	28
3.4 FIRE SUPPRESSION ACTIONS.....	33
4.0 DISCUSSION	36
4.1 TIME TO FAILURE FOR POLYETHYLENE TANKS	36
4.2 CORRELATION BETWEEN POLYETHYLENE WALL THICKNESS AND .. TIME TO FAILURE	38

TABLE OF CONTENTS (cont'd)

	<u>Page</u>
4.3 HEAT TRANSFER MECHANISMS	40
4.4 THE FIRE HAZARD - POLYETHYLENE vs STEEL TANKS	42
4.4.1 Fire Spread Rate For Polyethylene Tanks	42
4.4.2 Estimated Response Time Requirement	42
4.4.2.1. Polyethylene Tanks	42
4.4.2.2. Steel Tanks	44
5.0 CONCLUSIONS	46
REFERENCES	47
APPENDIX A - INSTRUMENTATION FOR TEST SERIES 43A1	A-1
APPENDIX B - TEST DATA FOR TEST SERIES 43	B-1

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Overall Views of the Deck Fire Area..... a. View Aft at the Deck Fire Area b. View Port at the Deck Fire Area	4
2	Detailed Views of the Fire Area..... a. Deck Fire Area and Splash Baffle b. Notch Valve for Overflow Control	5
3	Tank and Manhole Restraint System..... a. Steel Tank Restraint System b. Placement of Restraint Chains Over the Manhole	6
4	AFFF and Water Hose Streams..... a. Monitor on 02 Deck b. Manned Hose Streams	8
5	Carbon Dioxide Fire Suppression System... a. Corner Nozzle and Piping b. Cardox Tank on Load Cells	9
6	Localized Application of Carbon Dioxide.. a. Initial Attack on Fire b. Open Deck CO ² Blanket Over Fire	10
7	Flammable Fuel Dump Containment System... a. Containment Tanks b. Drain Below Fire Area	12
8	Oil and Fuel Containment Booms.....	13
9	Schematic Design Drawings for Steel Tanks.....	15
10	Schematic Design of Polyethylene Tanks...	16
11	Schematic Diagram of Test Tank Load Cell Assembly.....	18
12	Test Tank Load Cell Assembly..... a. Above Deck b. Below Deck	19
13	Schematic Diagram of In-Tank Thermocouple Locations.....	21
14	Time/Temperature Data for a Steel Tank Containing Ethyl Alcohol Exposed to a Small Fire.....	22

LIST OF FIGURES (cont'd)

<u>Figure</u>		<u>Page</u>
15	Typical Polyethylene Tank - Small Fire...	24/25
	a. Before.....	24
	b. Before. Detail of In-Tank Pressure Probe Locations.....	24
	c. After.....	25
	d. After.....	25
16	Typical Steel Tank - Small Fire.....	26/27
	a. Before.....	26
	b. During.....	26
	c. During.....	27
	d. After.....	27
17	Typical Polyethylene Tank - Large Fire	29/30
	a. Before.....	29
	b. Before Detail of Valving.....	29
	c. After. Collapsed Tank Structure....	30
	d. After. Residue in Fire Area.....	30
18	Typical Steel Tank - Large Fire.....	31/32
	a. Before.....	31
	b. During.....	31
	c. During.....	32
	d. After.....	32
19	Typical Tank Interaction Tests.....	34/35
	a. Before Fire.....	34
	b. During Fire.....	34
	c. After Fire.....	35
	d. After Fire.....	35
20	Predicted T_i for Polyethylene Tank Failure.....	39
21	Calculated Time to Failure as a Function of Minimum Container Thickness and Temperature.....	41
22	Square Close - Packed Cargo Array.....	42
23	Rate of Involvement of Flammable Fuel....	43

LIST OF TABLES

<u>Table</u>		<u>Page</u>
I	Fire Endurance for Polyethylene Tanks	
	a. Single Polyethylene.....	36
	b. Side-by-side Polyethylene Tanks...	36
II	Physical Data for Ethyl Alcohol.....	38
III	Minimum Thickness of Selected Commercial Polyethylene Containers...	38
IV	Comparison of Calculated and Experimental Time of Failure for Selected Commercial Polyethylene Containers.....	40
V	Experimental Times for Development of Plume Fires in Steel Tanks.....	45

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1.0 BACKGROUND

1.1 INTRODUCTION

In June 1984, the Department of Transportation amended DOT specification 34 to permit the use of polyethylene drums up to 55 gallons in capacity as authorized packagings for hazardous materials, including flammable liquids (1)*. The decision to authorize 55-gallon polyethylene drums was based, to a large extent, on tests performed by the U.S. Coast Guard in 1976 and 1977 (2). Even before DOT specification 34 was amended however, manufacturers of plastic portable tanks began to request DOT exemptions for their products, basing their request on the results of the drum tests (3,4). Some of these manufacturers have extrapolated the findings of these tests in order to justify a claim that a portable tank is a safer package than a drum.

The Marine Technical and Hazardous Material Division has endorsed the granting of exemptions for polyethylene portable tanks. Their use has been limited in marine transportation of corrosive and poisonous substances, and flammable liquids with a closed cup flashpoint not less than 73 deg F (23°C). The latter provision is imposed as a precaution but has no basis in either experience or testing. Therefore a research project was developed to provide information about the fire safety characteristics of commercial polyethylene tanks. The overall objectives and the technical approach used for this project are outlined in the following sections.

1.2 OBJECTIVES

The major objective of this project was to determine the fire safety characteristics of intermediate size polyethylene tanks containing flammable liquids. Specific technical objectives were to determine the fire resistance of rotationally molded polyethylene tanks containing flammable liquids with flashpoints above and below 73 deg F (23°C); and also, to compare the fire hazard potential of polyethylene and steel IBC tanks containing flammable liquids when used in the maritime industry. Questions to be addressed were:

- 0 Is the polyethylene portable tank a safe container for the carriage of intermediate flashpoint flammable liquids in marine transportation?
- 0 How does the polyethylene portable tank release its contents (fail) when subjected to external fire?

Does the tank wall weaken or melt before the pressure relief device functions?

* numbers in parenthesis indicate references contained in Section 5.

Does increasing the volume of the container from 55-gallon drums to 300-gallon tanks appreciably increase the time to release (failure?).

- 0 How does the fire resistance of a polyethylene container compare with the fire resistance of a steel DOT Specification 57 portable tank?

1.3 TECHNICAL APPROACH

In order to meet the project objectives, a series of full scale fire tests were conducted onboard the fire test ship MAYO E LYKES at Mobile, Alabama. The fire tests were divided into four tasks as follows:

- 0 Facility development.
- 0 Evaluation of 300 gallon steel tanks.
- 0 Evaluation of 300 gallon polyethylene tanks.
- 0 Inter-tank fire spread.

Three major test parameters were investigated: fire size, fuel type and materials used for tank construction.

Two types of exposure fires were used to evaluate the effect of different fire scenarios. The first used a four square foot fire placed directly under the center of the tank to simulate fires caused by a leaky valve or a small puncture in the tank wall. The second used a hundred square foot fire to simulate a tank engulfed in a large conflagration.

The effect of volatility and fuel type on onset of tank failure was determined by using two flammable liquids as tank contents: marine diesel and technical grade ethyl alcohol.

Finally, comparative tests were conducted to evaluate the relative fire safety of different construction materials. Two material types were evaluated: thermoplastic polyethylene and steel. For both materials the tanks tested were commercial IBC containers fabricated in accordance with current DOT regulations.

A variety of instrumentation was used to record major test parameters. These included: in-tank temperatures, in-tank pressures, weight loss, and heat flux. Documentary video tapes recorded the time of tank wall failure and fire fighting actions. Detailed descriptions of the facilities, instrumentation and test procedures are presented in Section 2. Results are outlined in Section 3. A brief discussion is provided in Section 4.

2.0 FACILITIES, MATERIALS, AND INSTRUMENTATION

2.1 FACILITIES

2.1.1 Deck Fire Facility

The simulated deck fire facility for this project was installed on the main deck of the MAYO LYKES. The area was located on the port side of the ship adjacent to the forward air castle. A 100 square foot area was isolated from the main deck by welding 1/4-inch steel plates to the deck. The plates were approximately 12 inches in height on the forward and starboard sides of the area. An additional six inches was added to the port side and half of the aft side of the area in order to accommodate the camber of the deck. The ship was positioned on a even keel in order to be able to measure the application rate of carbon dioxide. As a safety precaution, the fire area was surrounded by a "splash" baffle to limit the flow of spilled fuels to a confined area in the event of sudden overflow of the area caused by tank rupture. The splash baffle was also fabricated of 1/4-inch steel plate and was 24 inches high. The baffle plates were welded to the steel deck around the perimeter of the fire area at a spacing of 18 inches. The two notches in the sides of the fire area resulting from the 6-inch extension of the sides were designed to be at the same level and functioned as automatic overflow valves for the fire area. In operation, up to 600 gallons of fuel could be dumped suddenly into the fire area as a result of tank failure. The "notch" valves enabled the fuel overflow to be directed into the space between the sides of the fire area and the splash baffle. Both the fire area and the overflow reservoir had drain lines at their aft port corners. The drain lines lead directly to a set of four six-hundred gallon containment tanks. During operations, a protective water layer was put in the bottom of the fire area. Because of the camber of the deck the depth of water varied from 2 to about 9 inches. In effect, this procedure provided a level area and fuel for the exposure fire was floated on the water layer. The fuel used for all tests was marine diesel. For the small exposure fire, a 4 square foot pan was placed directly under the center of the tank, and a similar procedure was used for protection of the steel deck. An overall view of the fire area is shown in Figure 1a,b. Detailed views of the fire area are shown in Figure 2a,b. For the steel tanks, the manhole cover at the top consisted of a 55 gallon drum lid secured with a retaining ring. In order to restrain the movement of the lid and the tank to the immediate area of the fire, chains were used to secure the lid to the tank. The chains were attached to welded support mounts on the deck. The arrangement of the chains is shown in Figure 3. A similar arrangement was used on many of the tests using polyethylene tanks.

2.1.2 Fire Suppression Equipment

Fire fighting activities were necessary in order to extinguish the exposure, plume, and spilled fuel fires. Whenever

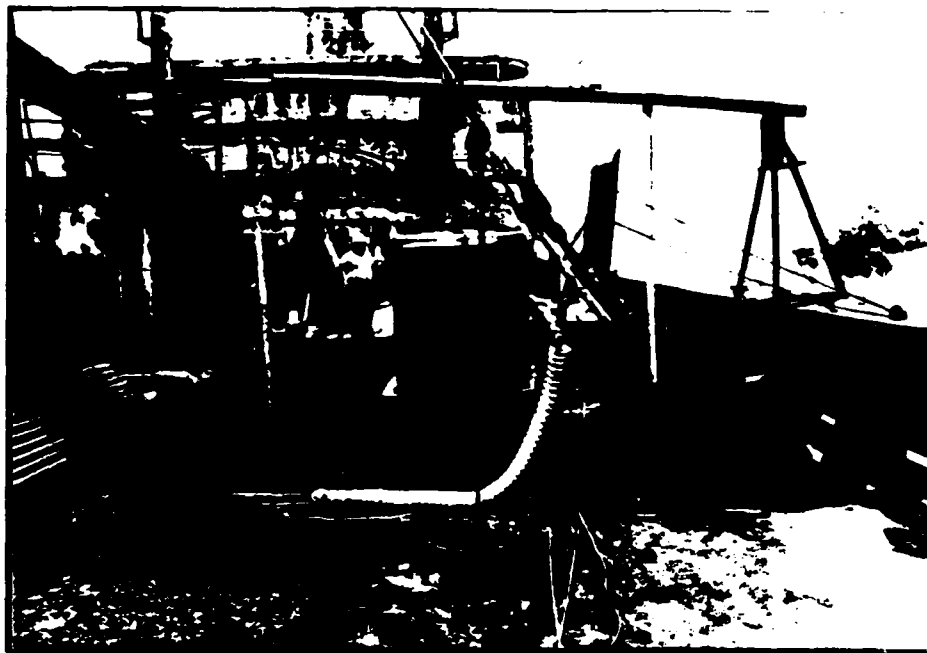


FIGURE 1a. View Aft at the Deck Fire Area

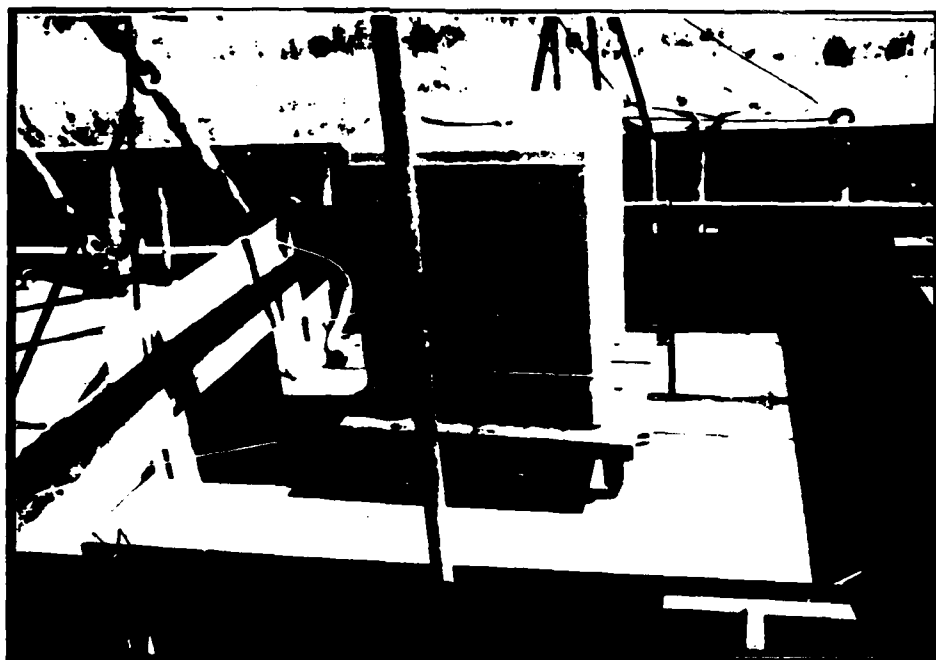


FIGURE 1b. View Port at the Fire Area

FIGURE 1. OVERALL VIEWS OF THE DECK FIRE AREA



FIGURE 2a. Deck Fire Area
Splash Baffle



FIGURE 2b. Notch Valve for Overflow Control

FIGURE 2. DETAILED VIEWS OF THE FIRE AREA

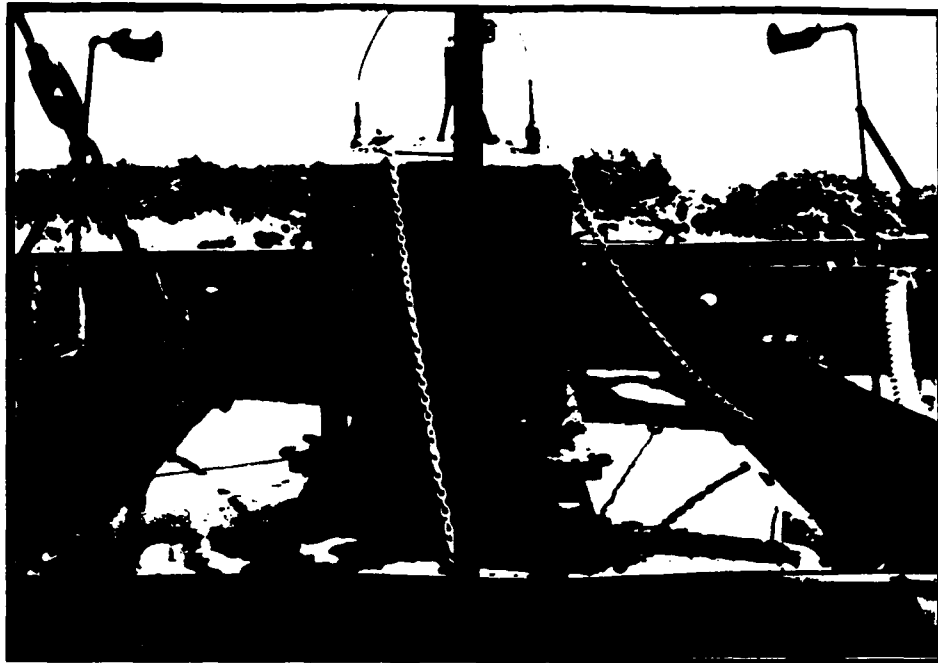


FIGURE 3a. Steel Tank Restraint System



FIGURE 3b. Placement of Restraint Chains Over the Manhole

FIGURE 3. TANK AND MANHOLE RESTRAINT SYSTEM

possible the need for extensive fire suppression actions by manned hose lines was minimized by limiting the fuel load in the exposure fire. For short duration tests this was accomplished by measuring the depth of fuel and estimating the linear regression rate of the fuel surface. For long duration fires a minimum layer of fuel was loaded into the fire area, and then a preset rate of fuel flow, from a remote location, was directed into the area in order to sustain the fire. At the end of each test hose lines were used to secure the fire area and to cool down the deck and ship superstructures. For the diesel oil exposure fire, 3% or 6% AFFF foam agents were used to secure the fire areas. Either concentration was about equally effective. Firefighting actions using AFFF or water are shown in Figure 4a from a monitor located on the 02 deck of the ships superstructure and for manned hose lines in Figure 4b.

Because of the unique safety hazards that were anticipated during these tests, special fire suppression capabilities were developed to augment the AFFF hose lines. The major concern was that of a tank explosion. This would require fire suppression systems that could be operated remotely from a secure location. Two systems were developed that could meet this requirement.

The first suppression system used a localized application of carbon dioxide. Since the fire tests were conducted on an open deck and subject to local winds, high volumetric flows of carbon dioxide were required. Initially, four discharge nozzles were installed at each corner of the fire area. Each nozzle was aimed at the center of the top surface of the exposure fire. After a series of initial test runs, two more nozzles were added. The two new streams were adjusted to impact each other directly above the top of the test tank. This change provided a more efficient extinguishment action for a three dimensional fire which is characteristic of the combined action of the exposure fire and the plume fires at the tank pressure relief vent port. A major advantage of the carbon dioxide system was that it provided a means of extinguishment of the test fires without imposing the polyethylene tank side walls to the large mechanical forces caused by impact of the hose streams. Therefore, the tank could be "frozen" in place for visual inspections after the fire to determine where the structural tank failure had occurred. The liquid CARDOX tank was suspended from a weight-load system to provide the capability of measuring carbon dioxide application rates. The total weight of the system varied from 11,500 to 24,500 lbs. depending on tank contents. The precision of measurement for 1000 lb. applications of CO_2 was ± 15 lbs., the major uncertainty in measurement being caused by local winds. An overall view of the placement of the high and low nozzles is shown in Figure 3a. A close up view of one of the corner nozzles and the distribution piping is shown in Figure 5a. The main Cardox tank suspended on load cells is shown in Figure 5b. The effective action of this system can be observed from Figure 6a, b.



FIGURE 4a. Monitor on 02 Deck

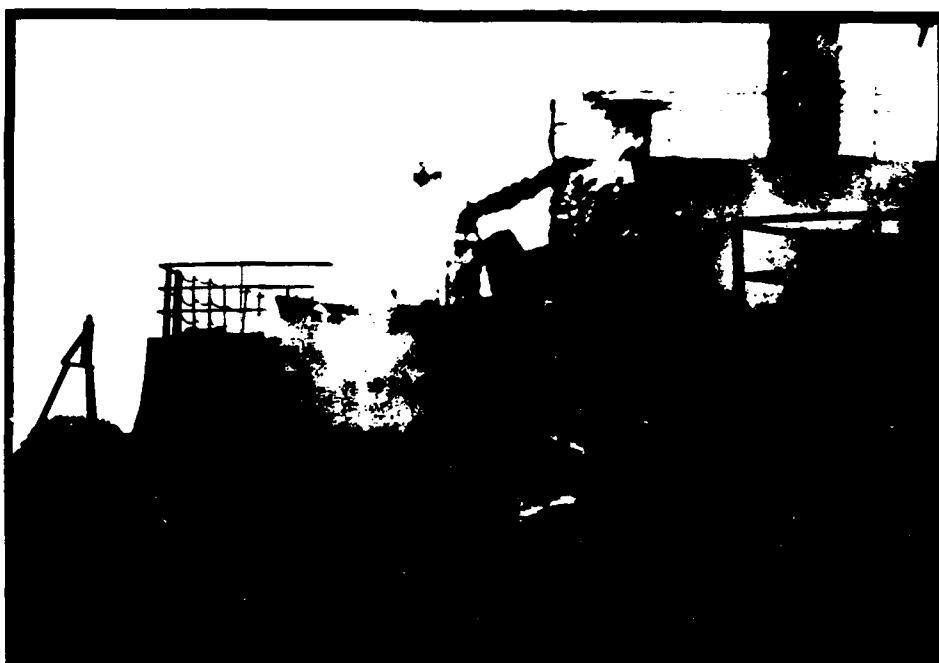


FIGURE 4b. Manned Hose Streams

FIGURE 4. AFFF AND WATER HOSE STREAMS

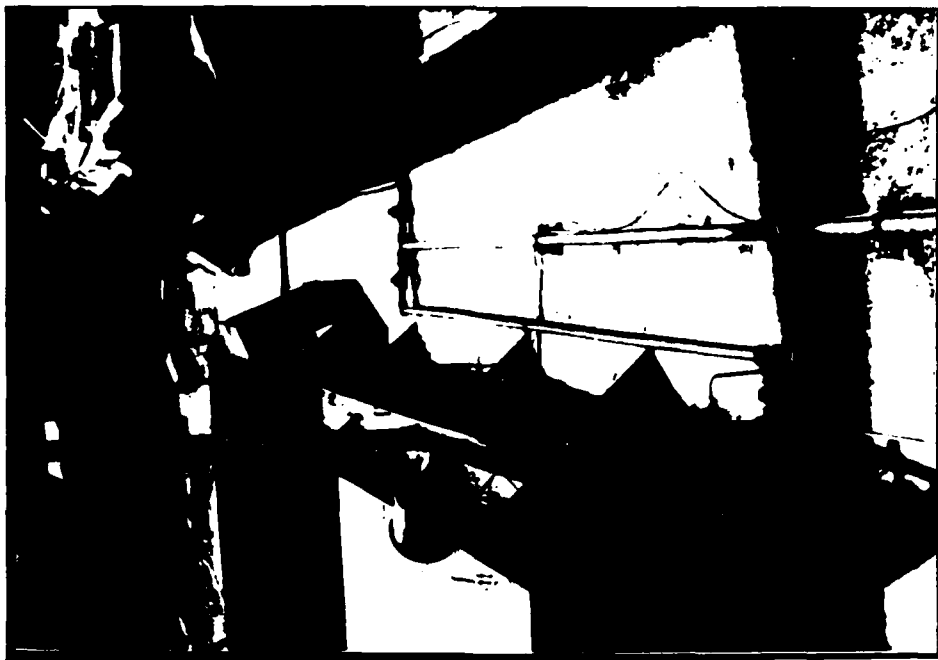


Figure 5a. Corner Nozzle And Piping



Figure 5b. Cardox Tank on Load Cells

FIGURE 5. CARBON DIOXIDE FIRE SUPPRESSION SYSTEM



FIGURE 6a. Initial Attack on Fire

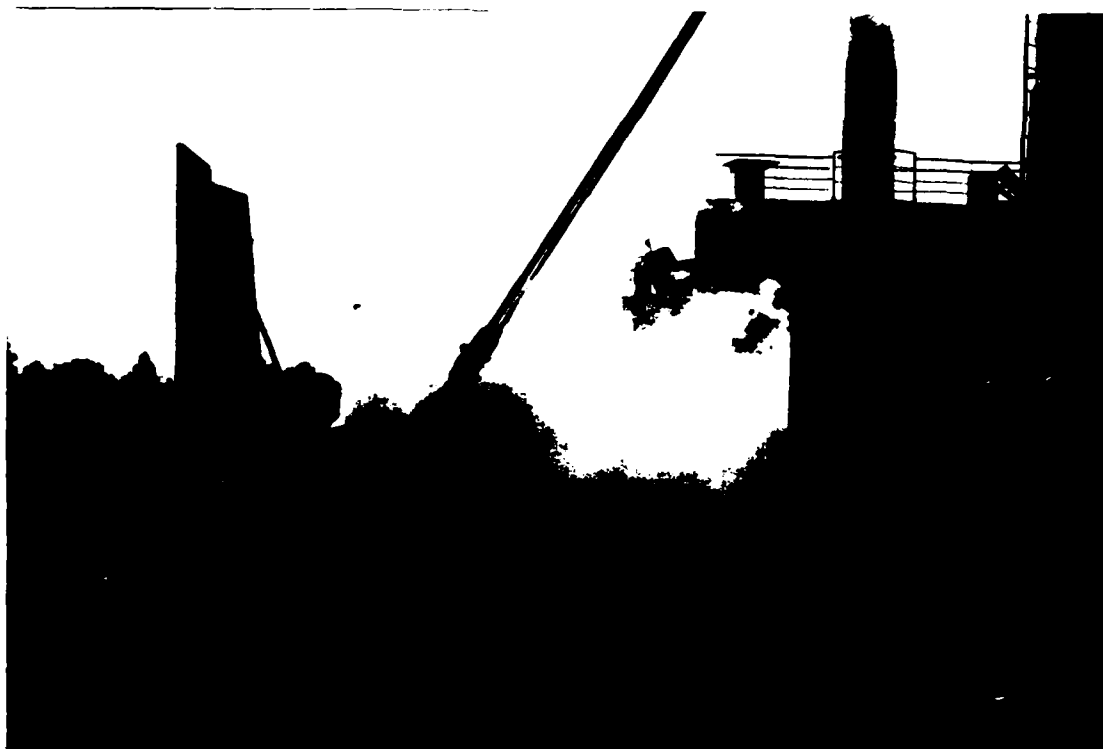


FIGURE 6b. Open Deck CO2 Blanket Over Fire

FIGURE 6. LOCALIZED APPLICATION OF CARBON DIOXIDE

The second method that was developed to provide remote extinguishment was a dump tank system. Drains placed in the bottom of the fire area and the surrounding splash baffle system were opened to drain the mixture of diesel oil and water together with the tank contents. The drains conducted the burning mixtures to a series of six hundred gallon dump tanks. Immediately before the dump, the tanks were purged and inerted by a discharge of carbon dioxide to prevent an explosion. Successful trial tests were conducted to ensure that this system could safely remove the flammable fuel wastes under fire conditions. An additional operational advantage was that this system enabled a faster turn-around between tests by minimizing the efforts necessary to clean up the work area before starting the next test. The four six-hundred gallon tanks used in this system were manifolded together to accommodate a total of 2400 gallons of wastes. These tanks and the drain lines are shown in Figures 7a,b.

2.1.3 Environmental Protection Equipment

The tests used hazardous materials both in the exposure fire fuels and tank contents. Air pollution was minimized by working under the operational guideline with respect to wind velocity and direction agreed to by the Environmental Protection Agency representatives in Mobile. The double containment system constructed for use as a fire area reduced the spillage of liquid hazardous materials to a minimum during and immediately after a fire test. The small quantities that did reach the deck and were washed overboard during fire fighting operations were contained by a water boom in the immediate vicinity of the ship. When necessary, they were absorbed by a commercial sorbent. Figure 8 shows the water boom placed between the ship and shore. The bulk of the waste fuels and contaminated water was drained into the holding tanks as previously described below the main deck in Hold #3. Periodically, these wastes were pumped aft to a second set of 1000 gallon holding tanks in Hold #4. At the end of the test series, these tanks were pumped out by a commercial bulk waste disposal company, and the tanks were cleaned. At the start of the tests these tanks were used to hold bulk quantities of marine diesel for use in the fire area. When needed these supplies were pumped forward. This procedure was designed to limit the quantity of flammable fuel to a minimum in the fire test area.

2.2 TEST MATERIALS

2.2.1 Exposure Fire Fuels and Tank Contents

Two hydrocarbon liquids were used on these tests to simulate either the exposure fire typical of a marine environment, or the tank contents of intermediate bulk container shipments of flammable fuels. These fuels were selected to provide information about the effect of flash point on tank failure times

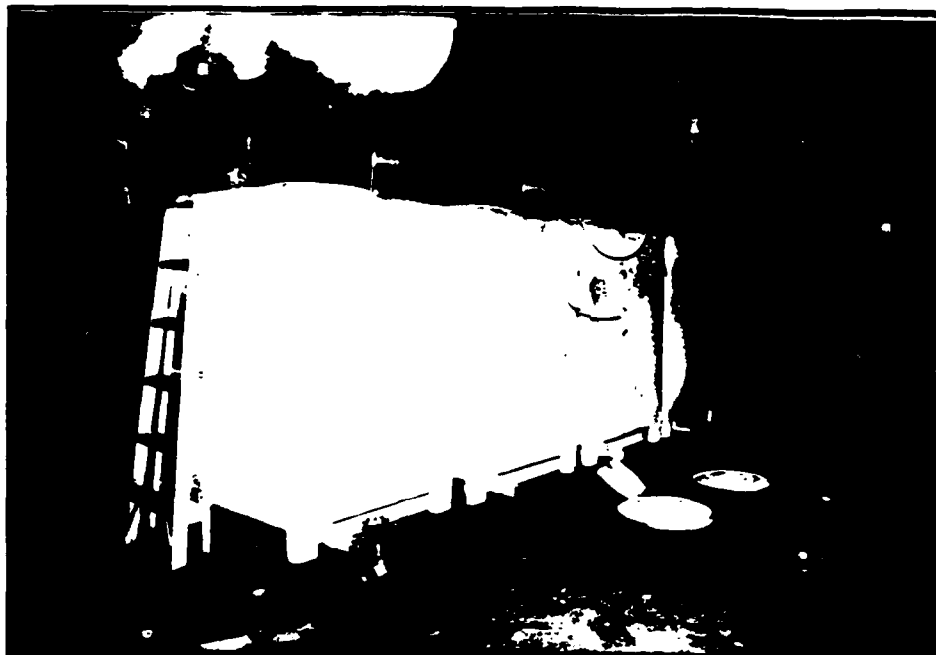


FIGURE 7a. Containment Tanks

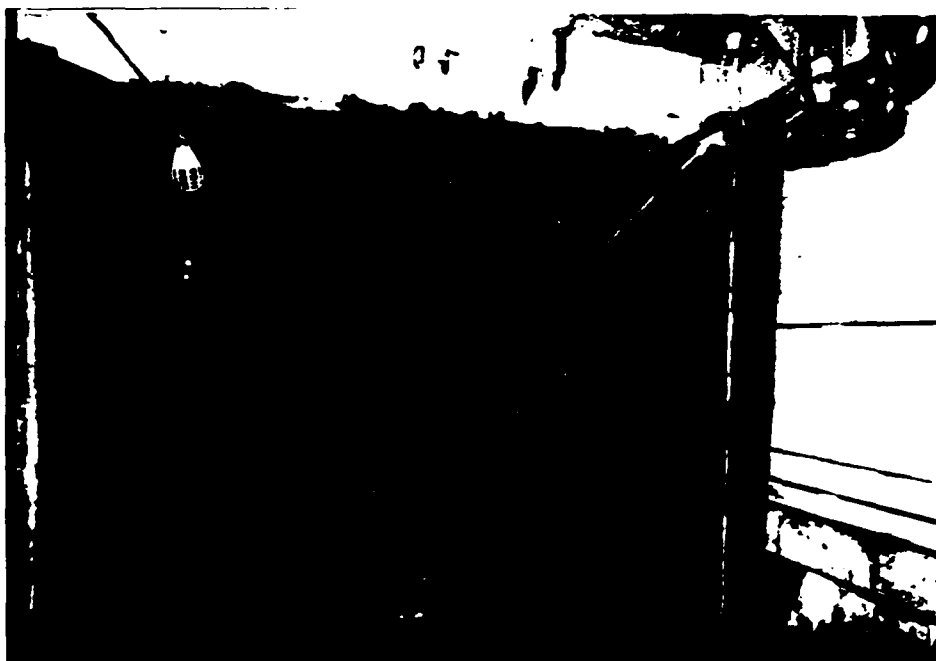


FIGURE 7b. Drain Below Fire Area

FIGURE 7. FLAMMABLE FUEL DUMP CONTAINMENT SYSTEM

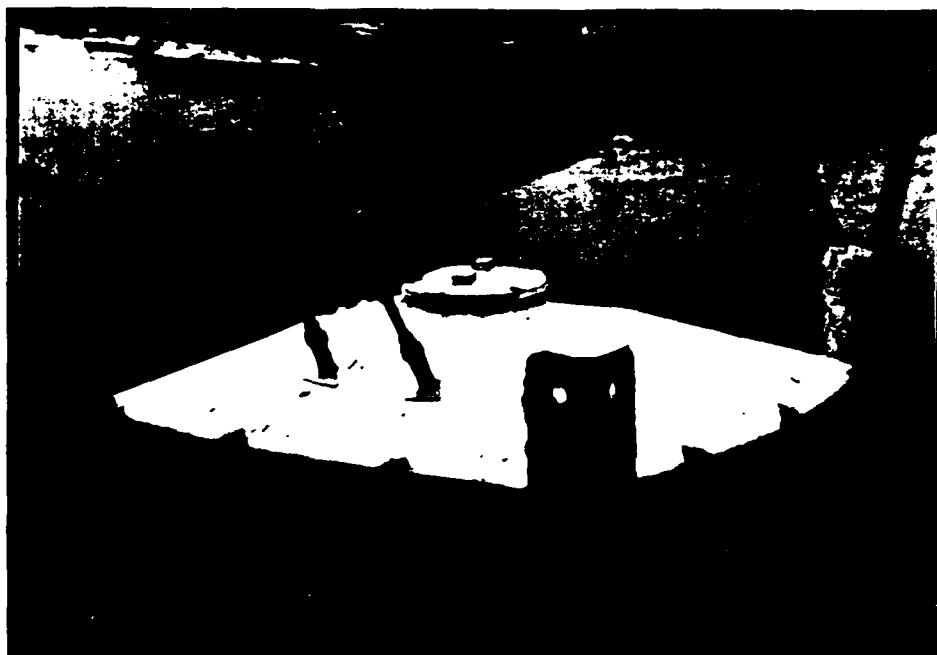


FIGURE 8. OIL AND FUEL CONTAINMENT BOOMS

for tanks containing flammable liquids with flash points greater than and less than 73°F (22.8°C). Marine diesel with a flash point of 107°F (41.6°C) was purchased from local marine terminal suppliers for use as both a typical exposure fire and as tank contents. Technical grade ethyl alcohol (95%) was used to simulate a more volatile tank content. The flash point of the ethyl alcohol was 63°F (17.2°C).

2.2.2 Steel Tanks

Steel tanks having a nominal capacity of 320 gallons were used on this project. The tanks were manufactured to order by Custom Metalcraft Inc., Springfield, Missouri. The tanks were DOT specification 57 tanks. The tanks were 42 inches by 42 inches by 49.5 inches high and fabricated from 10 gauge steel with double welded seams. Access to the tank was through a 22-inch drum opening at the top and through a 2-inch stainless steel ball valve at the bottom. During the fire tests the nipple from the ball valve was sealed using a standard steel plug. Before each test the tanks were filled with liquid to approximately the 42-inch level. The vapor space above the liquid surface was estimated to be 10% of the total tank volume. The top of the tank contained a pressure relief plug designed to actuate when either excessive temperatures or pressures were reached. The relief vent was a 2-inch polyethylene combination burst disk and fusible plug and was set for actuation at 9 psig. Figure 9 shows a schematic drawing of the steel tanks.

2.2.3 Polyethylene Tanks

Polyethylene tanks having a nominal capacity of 300 gallons were used on this project. The tanks were manufactured by Poly Corr, Inc, Monroe, Louisiana. The tanks were DOT approved for use with corrosive materials. The tanks were cubical in shape and were fitted into stackable metal frames. The tanks dimensions were 42 inches in width, 48 inches in length by 57 1/2 inches in height with the carrier in place. The nominal wall thickness was 3/8 inches. The tanks were made from high density polyethylene and were designed to be filled within 10 inches of the top. At this level the ullage was 10% of the total volume. Weight of the tanks was 135 lbs. Weight with carrier was 550 lbs. Figure 10 is a schematic drawing of the tank.

2.3 INSTRUMENTATION

A variety of instrumentation was developed for this project. Appendix A lists the instrumentation used and provides a brief description of each major equipment item. The instrumentation can be divided into four major use categories: (1) Test Parameters, (2) Facility Operating Parameters, (3) Facility

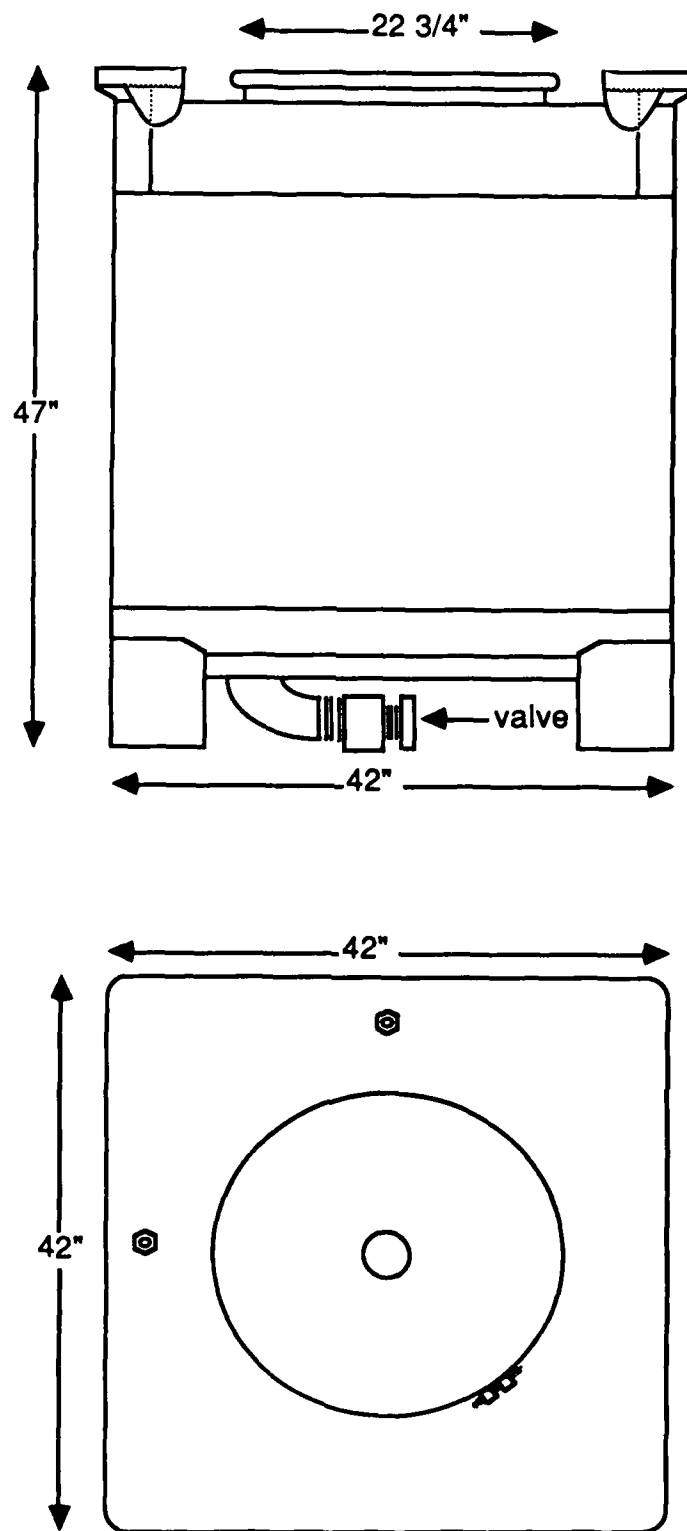


FIGURE 9. Schematic Design Drawings for Steel Tanks

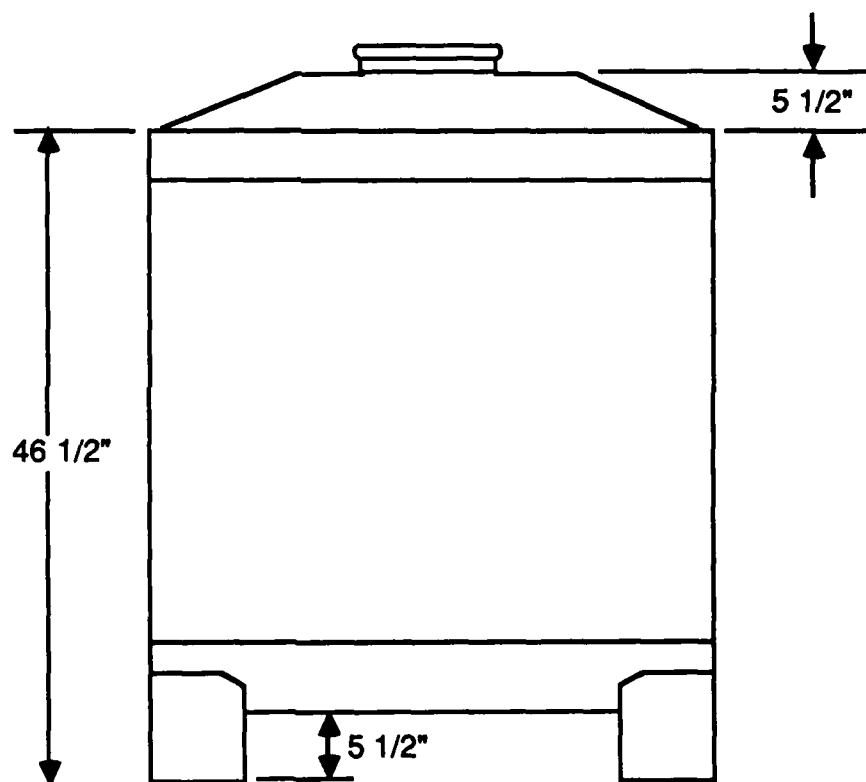


FIGURE 10. Schematic Design of Polyethylene Tanks

Safety, and (4) Facility Development. Since it was not possible to make changes in the data channel assignments during the tests, several channels were assigned as "spares" to allow for on site modification of the site procedures. Typical instrumentation required for facility development included pressure transducers (Channels 9 through 16) used in the carbon dioxide extinguishment system, and thermocouples that were used to monitor temperatures on pressure and heat flux transducers. Instrumentation used to ensure facility operating safety included; the monitoring of carbon dioxide concentrations in closed areas below deck, and the total hydrocarbon concentrations at selected locations. Since these safety channels were required both before and after the actual tests, it was necessary to modify the normal operating procedures for the computer and to continue scanning for relatively long periods of time. In one case this practice prevented the build up of explosive concentrations of fuel below decks which resulted from an unexpected volatilization of flammable fuel caused by solar heating. Facility operating parameters included: wind direction, and speed, line frequency, and voltage values. Test data parameters included: dynamic weight loss of the test tanks, in-tank pressures, in-tank temperature profiles, and radiant heat flux directed into the tank from the exposure fires.

2.3.1 Tank Weight-Loss Instrumentation

In order to be able to measure the rate of loss of the tank contents, the test tanks were installed on four load cells, one at each corner of the tank. Each cell had a capacity of 0 to 5000 lbs. The load cells were in contact with the support frame for the test tank. The weight of the tank was transmitted to the load cells using a steel pipe assembly which extended through the deck. Figure 11 shows a schematic diagram of the system. Above deck the force rod assembly consisted of three concentric pipes. The inner pipe (1.5 inches) was welded to the end wall plate on the outer pipe (2.5 inches). The inner pipe was then inserted into a center pipe (2.0 inches) which was welded through the deck plates. Sufficient clearance between the pipes (0.15 inches) minimized false readings caused by lateral side forces. Figures 12a,b show the support assembly above and below deck. Above deck, the tank, support frame, and steel pipe assembly are shown in place for a test. The height of the frame was adjusted so that flammable fuel could not overflow by going down the support shaft to the deck below. Below deck, the overhead height was approximately fourteen feet. With the close spacing between the different sections of the support assembly, the long concentric close fitting shafts tended to bind if the main deck buckled due to heat. To prevent this, water streams were used to cool the main deck for some tests. When not used under high heating conditions, deflections of up to 6 inches would occasionally occur in the main deck. A second problem resulted from the difference in the pitch of the main deck and the cargo hold deck. To accommodate this differential, expansion wood blocks were used to shim the load cells.

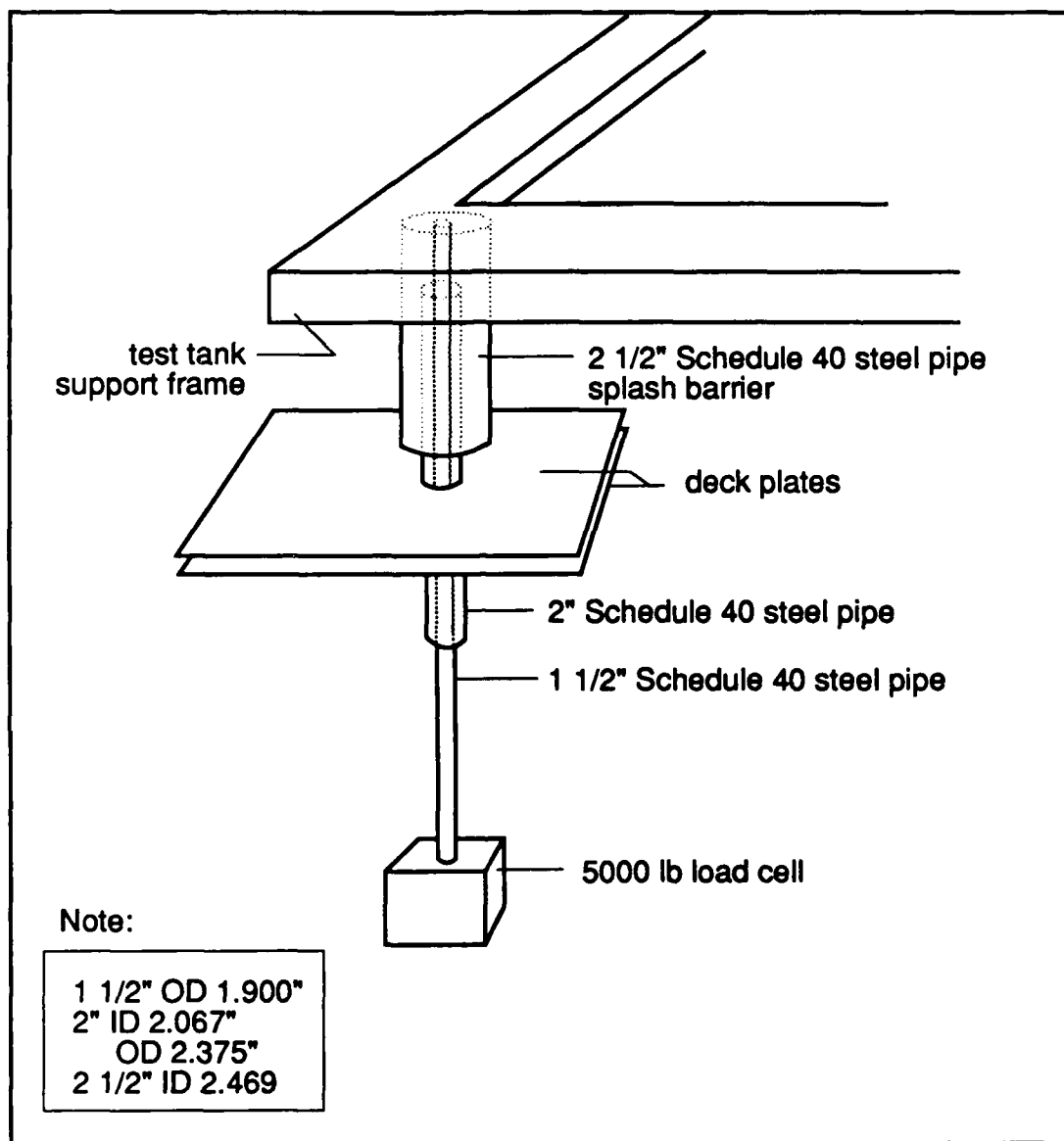


FIGURE 11. Schematic Diagram of Load Cell Thrust Assembly

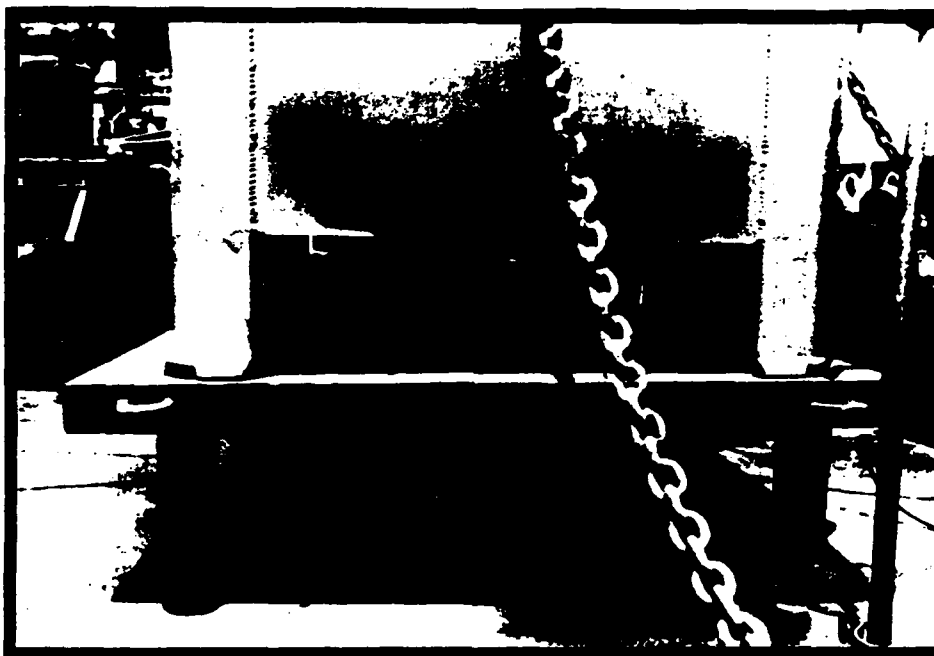


FIGURE 12a. Above Deck

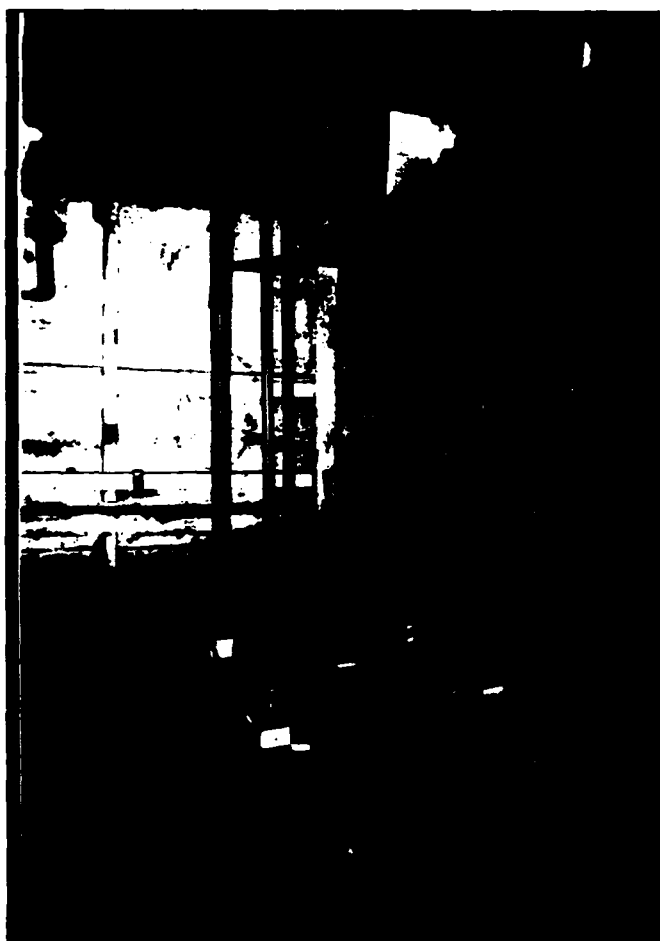


FIGURE 12b. Below Deck

FIGURE 12. TEST TANK LOAD CELL ASSEMBLY

2.3.2 In-Tank Temperature Measurements

The temperature of the tank contents was measured using Type K thermocouples. The thermocouples were installed inside the tank on a "christmas tree" thermocouple rake consisting of an array of five thermocouples spaced across the center line of the tank and a set of four thermocouples placed vertically through the tank center. The vertical rake consisted of four thermocouples; #42, #48, #41, and #43. Thermocouple 42 was located in the tank ullage space between 2.5 to 5.0 cm from the tank top. Thermocouple 43 was positioned 2.5 cm from the bottom. Thermocouple 41 was in the center and was common to both the vertical and horizontal rakes. Thermocouple 48 was installed half way between 42 and 41. The horizontal array of five thermocouples with thermocouples 44 and 45 placed 2.5 cm from the side walls and thermocouples 46 and 47 installed half way between the center and the outlying side wall thermocouples. The thermocouples were wired in place on a wood cross which was folded in order to be inserted in through the top tank opening and "expanded" once inside the tank to meet the above specifications for positioning. All thermocouples were shielded and grounded. A schematic diagram of the thermocouple placement is given in Figure 13. Figure 14 shows a typical time/temperature curve for a steel tank containing ethyl alcohol during a small fire test.

2.3.3 In-Tank Ullage Pressure Measurements

During the tests the vapor space at the top of the tank was instrumented to record the in-tank ullage pressure. The rate of rise of the pressure provided information about the thermal input to the tank contents and whether the pressure relief vent systems had actuated. Two SENTRA IO3, Model 205-2 pressure transducers were installed in the tank. In order to reduce the heat load to the transducers the ullage was connected to the transducers through a length of stainless steel flexible tubing and pipe. The transducers were then installed in a protected area about 15 feet above and away from the fire area. During initial testing there was occasional condensation in the line which resulted in inaccurate readings. This was corrected by ensuring that the lines were pitched upward to allow return of condensates to the tank volume. A minimum of 1/2 inch flexible tubing was required to prevent formation of liquid plugs during testing.

2.3.4 Video/Photographic Documentation

Video was used to document the test fire and assist in the determination of time of tank failure and mode of tank failure. Three video positions were used. One camera was located on the 03 deck viewing forward. A second camera was located on the 04 deck viewing forward. And a third camera was positioned on the main deck viewing aft. The 03 and 04 cameras provided an overhead view. The main deck camera provided close up views of the tank top and vent ports. Because of variable winds, smoke obscured the view on a number of tests; however, one of the

NOTES:

#41 Center

#43,44,45 1 inch from tank wall

#42 1 inch from top of tank (in ullage)

#46,47,48 1/2 the distance between #41 and the Tank Wall

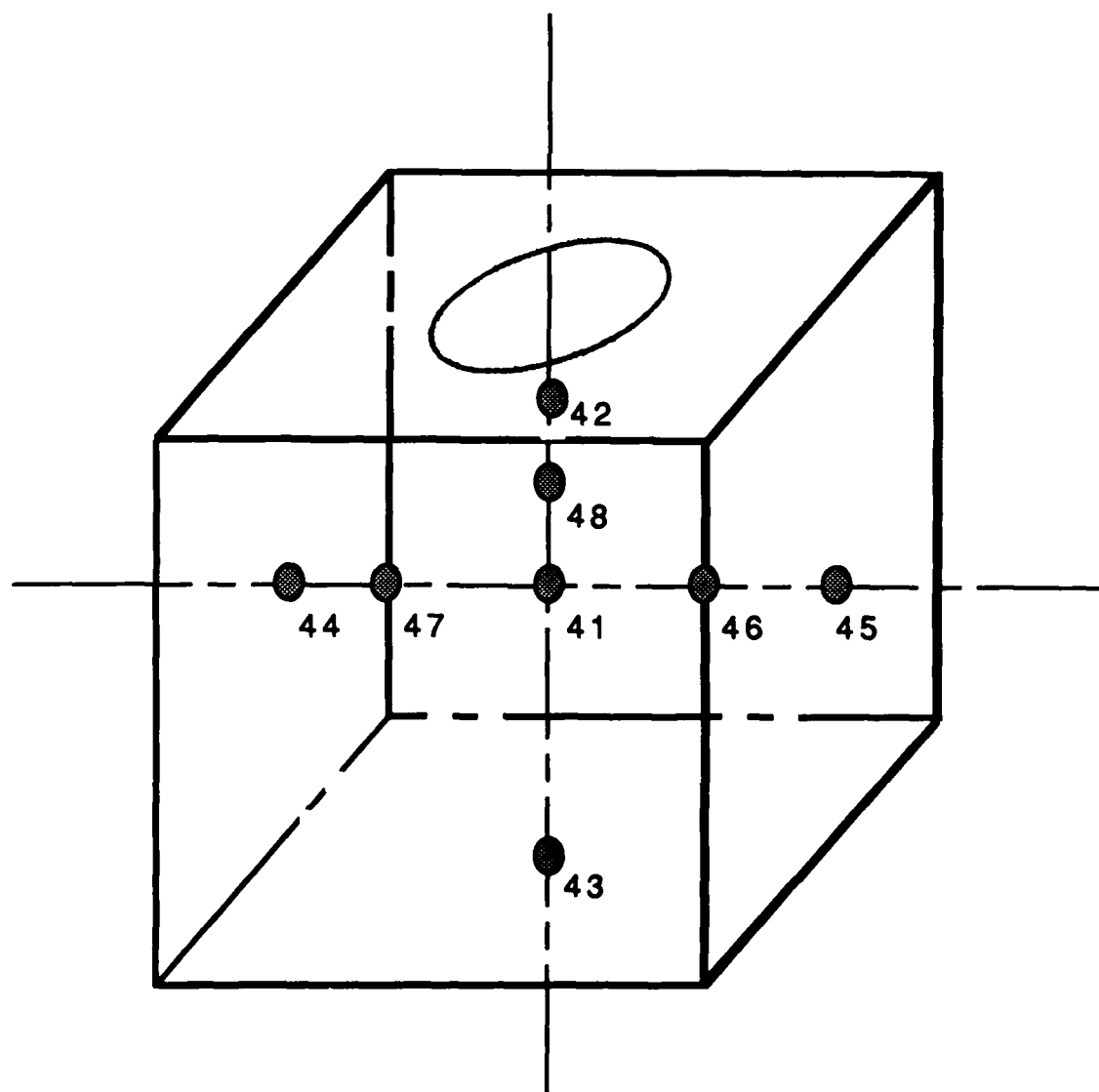


FIGURE 13. Schematic Diagram of In-Tank Thermocouple Locations

TANK TESTS

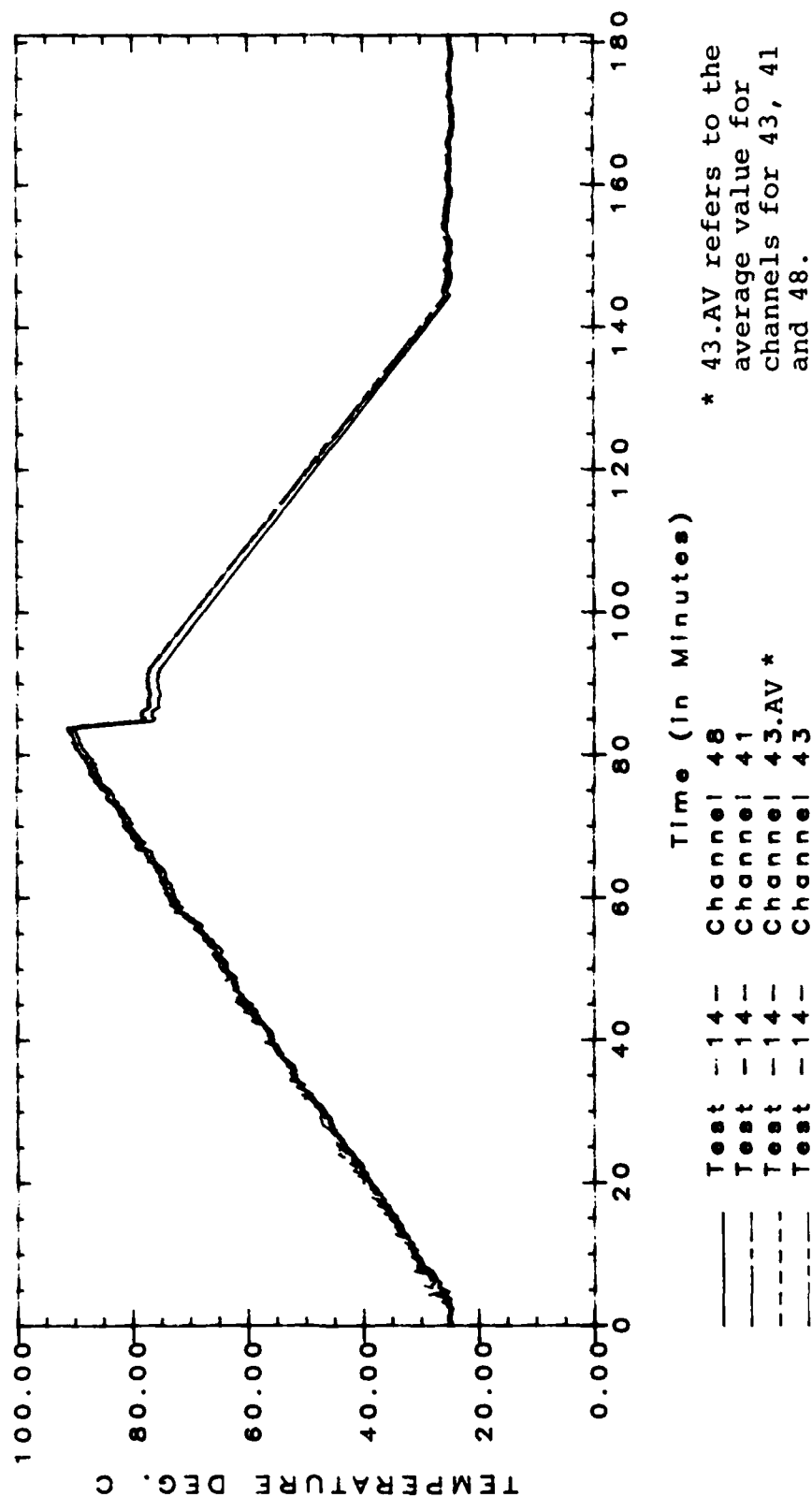


Figure 14. Time/Temperature Data for a Steel Tank Containing Ethyl Alcohol Exposed to a Small Fire

cameras was usually able to provide a clear view of the fire. The video coverage was supplemented by still photographs both during tests and to document the experimental arrangements.

3.0 RESULTS

3.1 SMALL EXPOSURE FIRE TESTS

3.1.1 Polyethylene Tanks

Three tests were conducted using polyethylene tanks exposed to a four square foot fire. Two tests were run using ethyl alcohol as contents. One test was made using marine diesel fuel oil. Failure times for the ethyl alcohol contents were 5'18"* for Test 22 and 4'46" for Test 23. Failure time of the tank containing marine diesel was 5'44". Figure 15 shows views of typical polyethylene single tank tests before and after the fire. Specific data for the tests is outlined in Appendix B. Within experimental error, the data indicate that differences in the volatility or flash point of the tank contents do not affect the time to tank failure. There was no indication that significant heat transfer occurred from the fire to the tank contents prior to tank failure.

3.1.2 Steel Tanks

Five tests were made to investigate the effects of a small four square foot fire on commercial steel tanks. Tests 10 and 11 used marine diesel for flammable contents. On Test 10, there was a gradual increase in temperature in the contents reaching 90°C after about 45 minutes when the test was cut off. The tank did not have a cap on the valve outlet and a leak in the valve occurred at that time. Similar results were obtained on Test 11. Test 11 was cut off after 110 minutes with a temperature rise from 30°C to 118°C. No damage was sustained by the tank as a result of either test. The internal pressure in Test 11 rose 12 psig during the test. The tank was rated for an operating pressure of 6 psig and the vent relief did not actuate at 6 psig. Tests 13, 14 and 15 used ethyl alcohol. The general characteristics of the fire safety of the tanks were similar. First there was a long period of heating which was followed by the development of a strong plume fire. The plume fire reached heights up to 75 feet above the main deck with afterburning of the fuel vapors expelled from the tank to an estimated 125 feet. None of the tanks failed before the plume fire developed. Overpressures of 16 and 26 psig were reached in the ullage of Tanks 13 and 15 respectively, even though the rated operating pressure of the tank is 6 psig and the vent relief should have functioned earlier. The time of plume development was directly related to the time of vent relief varying from 38'48" for Test 13 to 2 hours 20'56" for Test 15. Test 14 was intermediate and vented at 1 hour 23'49". Figure 16 shows four views of typical steel tank fire characteristics.

* 5'8" refers to 5 minutes 18 seconds

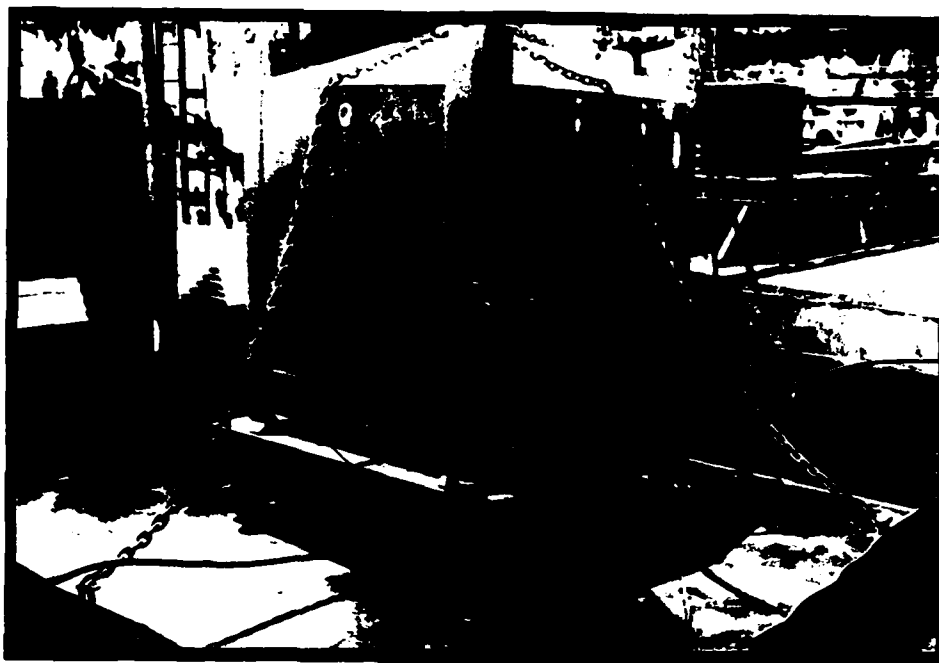


FIGURE 15a. Before

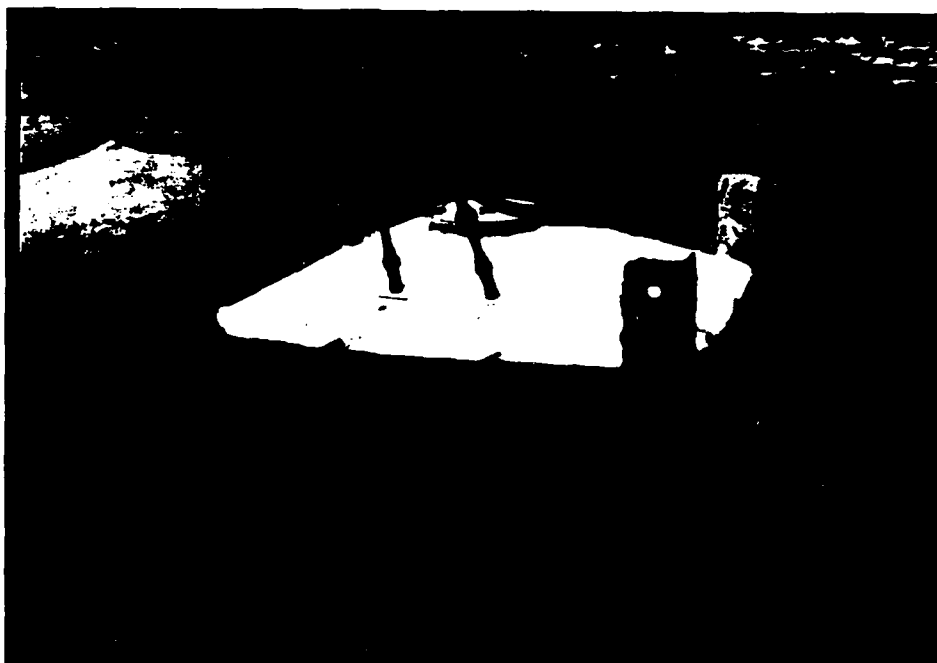


FIGURE 15b. Before. Detail of In-Tank Pressure Probe Locations

FIGURE 15. TYPICAL POLYETHYLENE TANK - SMALL FIRE

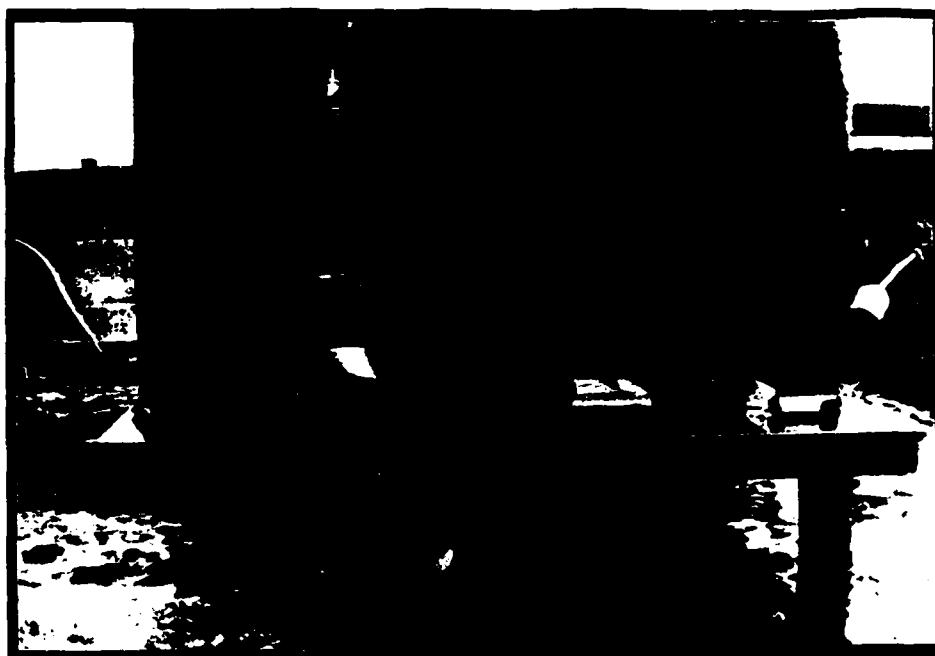


FIGURE 15c. After



FIGURE 15d. After

FIGURE 15. TYPICAL POLYETHYLENE TANK - SMALL FIRE (cont'd)

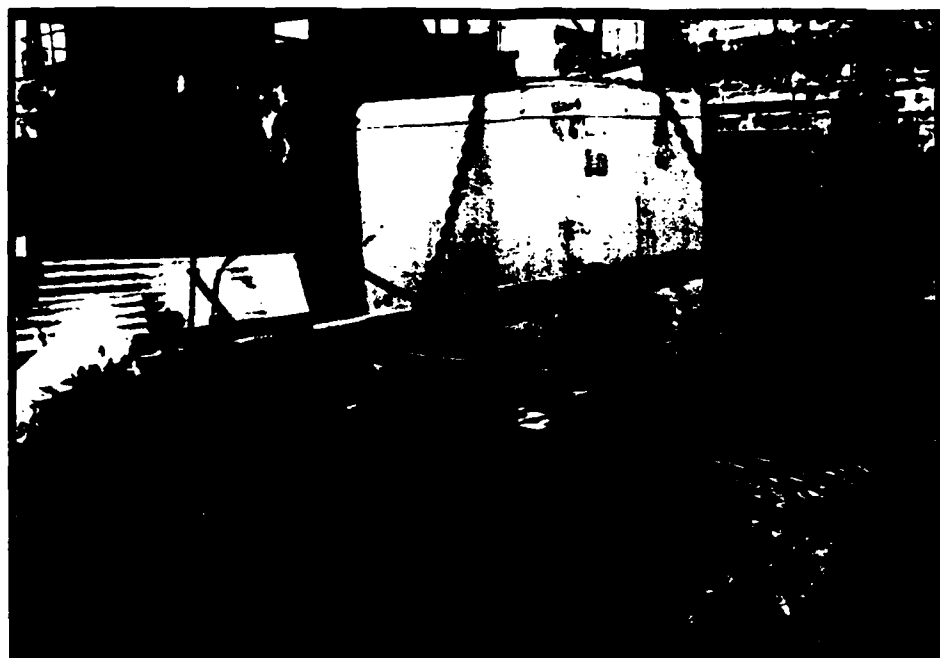


FIGURE 16a. Before

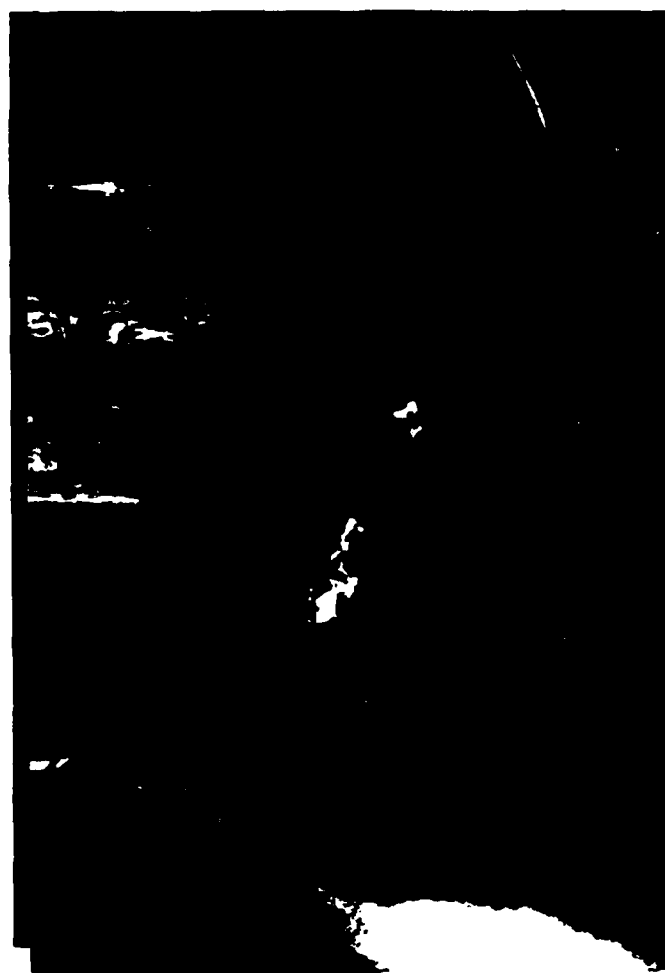


FIGURE 16b. During

FIGURE 16. TYPICAL STEEL TANK - SMALL FIRE



FIGURE 16c. During

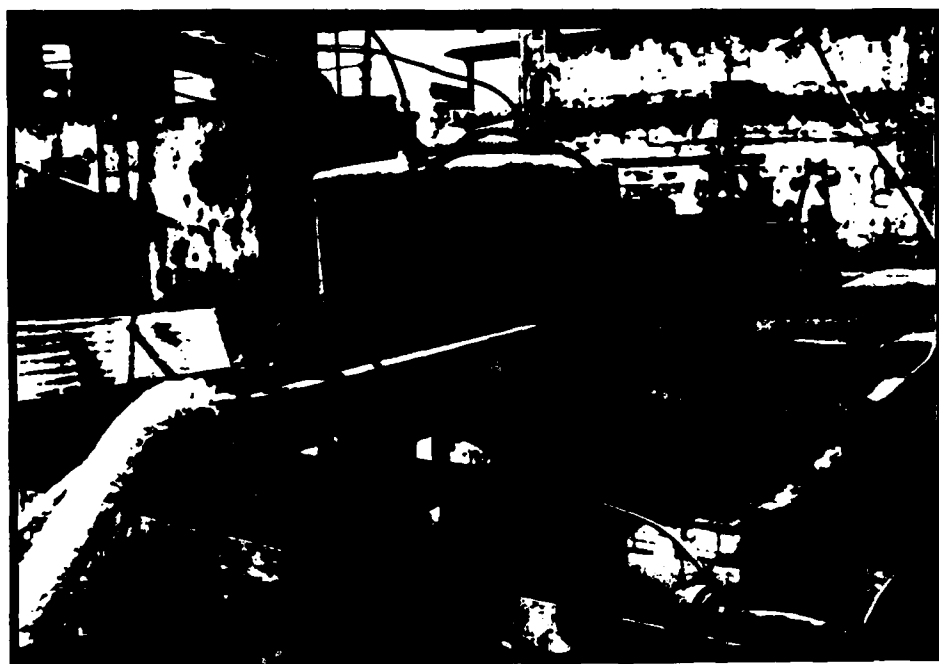


FIGURE 16d. After

FIGURE 16. TYPICAL STEEL TANK - SMALL FIRE (cont'd)

3.2 LARGE EXPOSURE FIRE TESTS

3.2.1 Polyethylene Tanks

Three tests were conducted to determine the time to failure for polyethylene tanks exposed to 100 square foot fires. Tests 16 and 17 used marine diesel fuel for tank contents. Test 19 used ethyl alcohol. The time to failure for Tests 16 and 17 was 6'25" and 4'25" respectively. On Test 16, the tank failed at the top at 4'45" as recorded by visual video observations and released its load at 6'25". Tank failure for Test 19 occurred at 5 minutes as determined by load cell data. Again no particular significance is attached to the time differences that can be interpreted as dependency upon flash point or fuel volatility within the range tested. Figure 17 shows the polyethylene tanks that were exposed to 100 square foot fires. Technical data is documented in Appendix B. A detail of the tank outlet valving is shown in Figure 17b. Initial tank failure occurred at this point or at the tank top.

3.2.2 Steel Tanks

Four tests were made using steel tanks exposed to a 100 square foot fire. Tests 5 and 6 contained marine diesel as flammable contents. For these tanks there was a gradual increase in temperature and pressure. For Test 5 the valve vented after 9 minutes and a plume fire developed after 22 minutes. For Test 6 there was a gradual increase in the temperature of the tank contents to 220°C after 30 minutes and the early thermal rupture of the vent relief plug followed by a gradual development of fire on the tank top. Tests 7 and 8 used ethyl alcohol as the flammable contents. In both cases there was a rapid build up in pressure resulting in the rupture of the relief vent at about 2 minutes and the development of a plume fire within 6 minutes. The fire plume self extinguished when the exposure fire was allowed to terminate at 26 minutes. For all four tests, there was minimal damage to the steel tanks during the fire tests. The principal hazard was associated with the plume fire. Since the relief vent melted soon after the fire exposure began the in-tank pressure remained close to atmospheric and a high plume did not result until a long time period had elapsed. Figure 18 shows four views of a steel tank exposed to a large fire. No structural damage occurred to the tank which could cause release of large quantities of fuel over the deck.

3.3 INTERACTIONS BETWEEN POLYETHYLENE TANKS

Three test were conducted to determine the failure time for two adjacent tanks. All tests were conducted using a four square foot fire exposure. The tanks were positioned with less than one foot separation between side walls. Because of test facility

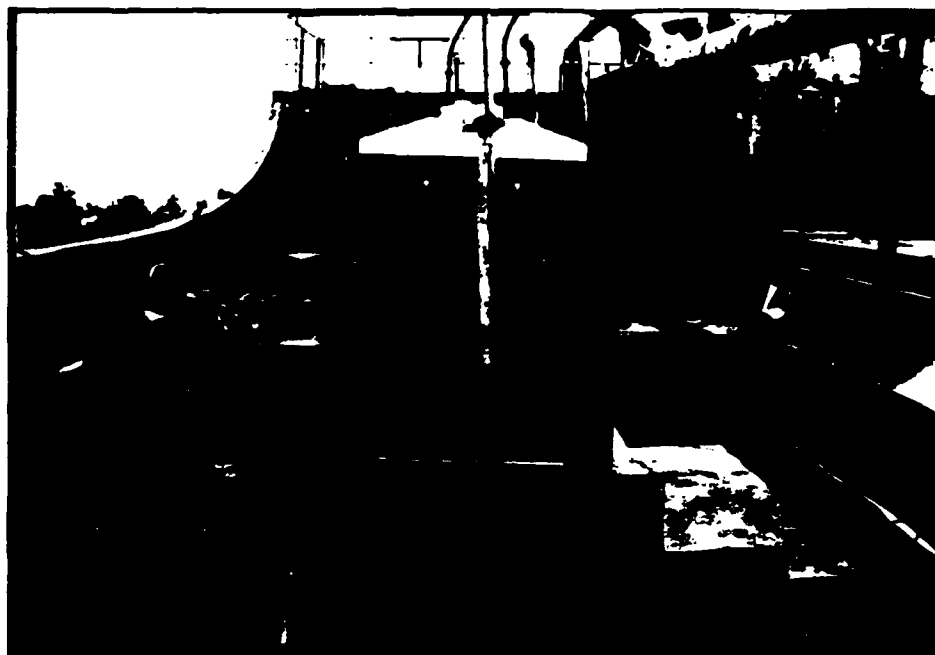


FIGURE 17a. Before

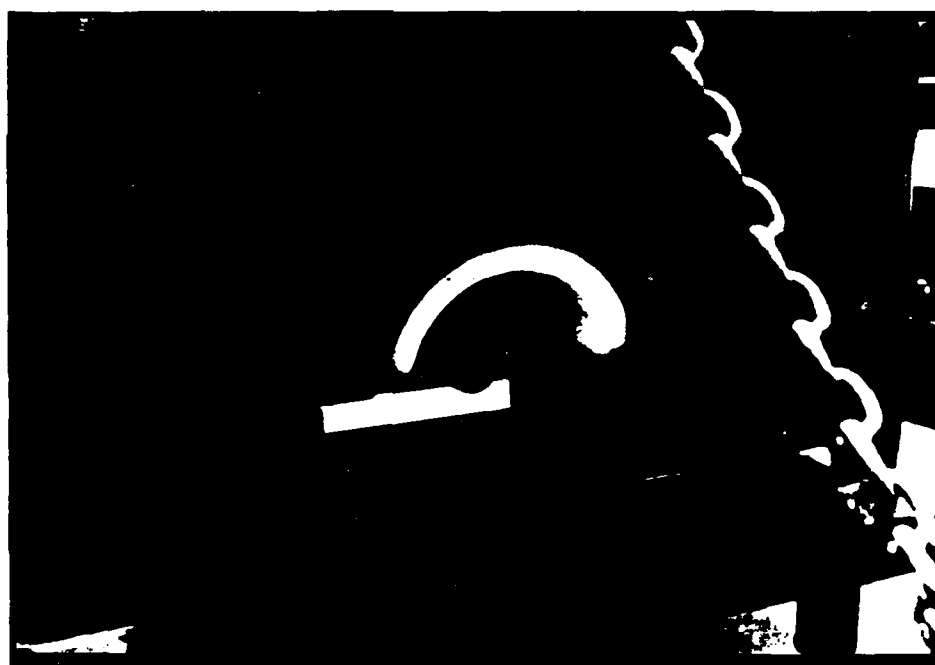


FIGURE 17b. Before. Detail of Valving

FIGURE 17. TYPICAL POLYETHYLENE TANK - LARGE FIRE

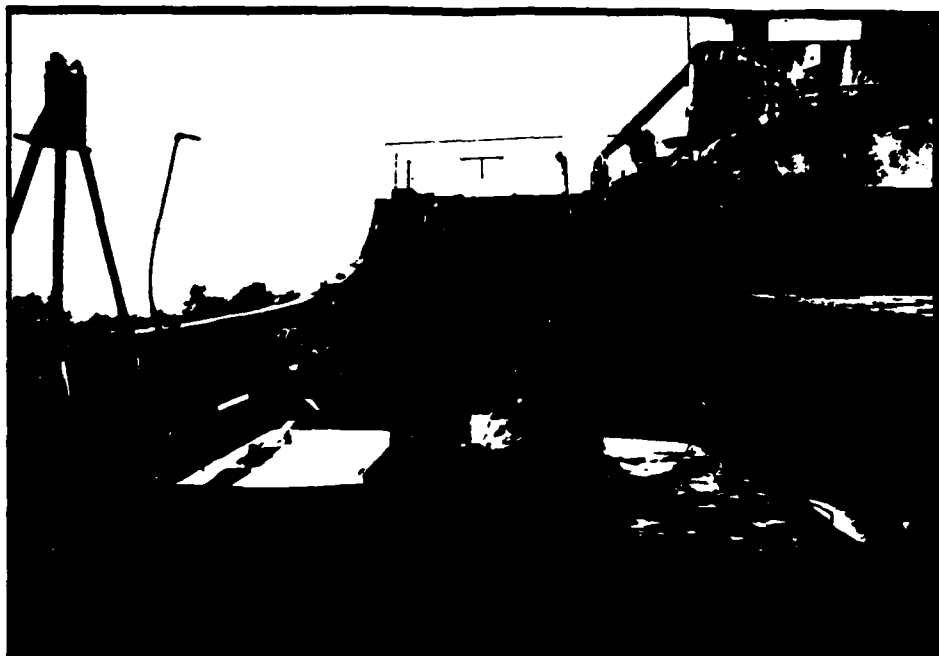


FIGURE 17c. After. Collapsed Tank Structure



FIGURE 17d. After. Residue in Fire Area

FIGURE 17. TYPICAL POLYETHYLENE TANK - LARGE FIRE (cont'd)

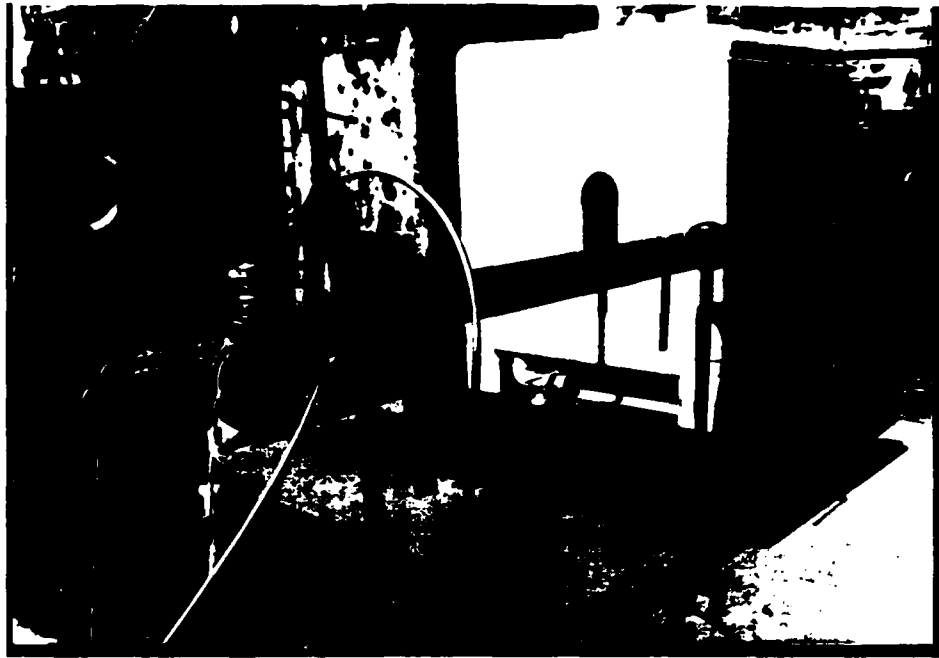


FIGURE 18a. Before

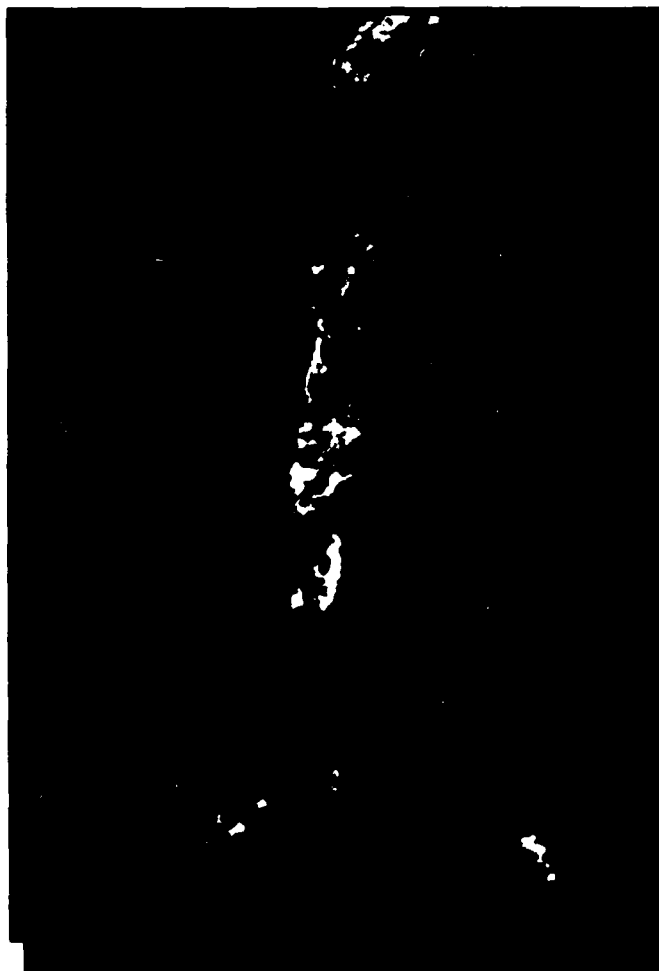


FIGURE 18b. During

FIGURE 18. TYPICAL STEEL TANK - LARGE FIRE

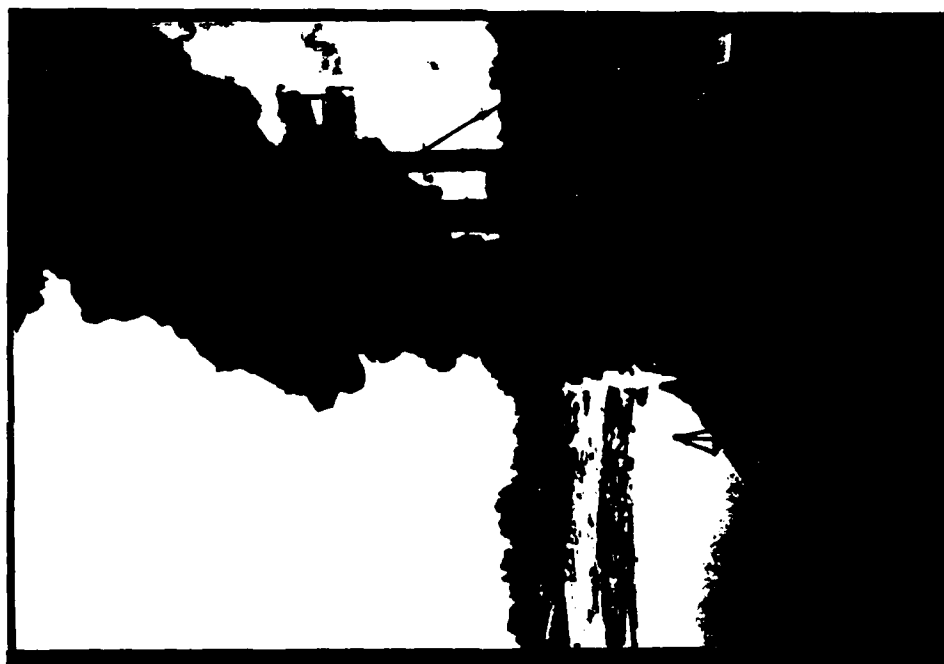


FIGURE 18c. During



FIGURE 18d. After

FIGURE 18. TYPICAL STEEL TANK - LARGE FIRE (cont'd)

limitations, the load of the outboard tank rested partly on the main deck, and the load cell data does not provide an accurate total weight. For Test 26, ethyl alcohol was used in the inboard tank. Tank failure time for the inboard tank was 5'12" from video data, and 5'05" using load cell data. Failure of the outboard tank was observed visually about 3 minutes afterwards. Tests 27 and 29 used marine diesel as tank contents. The positioning of the tanks was the same as described previously. Failure time for Test 29 was 5'10". Again the time to failure of the outboard tank was approximately 3 to 4 minutes later as determined visually. For Test 27, failure time of the inboard tank was 7'30" from internal tank pressure measurements and 8' 10" from visual video analysis. The outboard tank containing water did not fail. The reason for the lack of failure is the reduction in fire in the area caused by dilution of the alcohol fuel contents with the water blanket used to protect the main deck. For these tests there was a consistency of results with respect to the previous series with single polyethylene tanks. Figure 19 shows four views of test fires involving two polyethylene tanks.

3.4 FIRE SUPPRESSION ACTIONS

Fire fighting actions were a necessary part of the test project. Three methods were used both to extinguish the fire at the end of a test with a minimum of damage to the facility and to evaluate alternative fire suppression techniques required to maintain facility safety. The use of a localized application of carbon dioxide was successful. Since the application was made out of doors sufficient agent had to be applied to maintain extinguishment long enough to enable cooling. In practice, holding times of 5 to 10 minutes were possible, the length of time depending on wind conditions. This method was developed to provide remote fire suppression capability in the event of the need for action at a time when a tank explosion was possible. The second method involved an inerting system in which the exposure fire fuel and the liquid tank contents were conveyed to an inerted reservoir tank. This system worked very effectively during feasibility tests, but was not required during testing. Finally, the third method using AFFF foam and water or water fog nozzles was used. Because of low cost and high effectiveness, hose streams were used throughout the tests both to extinguish plume fires and to control and extinguish fires in the test area and tankage. When extinguishing fires in polyethylene tanks, there was a tendency for the tank to reflash. In some cases, this reflashing occurred over a period of 15 to 20 minutes. The primary reason for the reflashing was the trapping of flammable fuels in folds of melted plastic. Hose streams directed into the tank were not effective in extinguishing the fire. Since the hose streams were manned by highly skilled research personnel, their inability to extinguish the fires was considered significant.

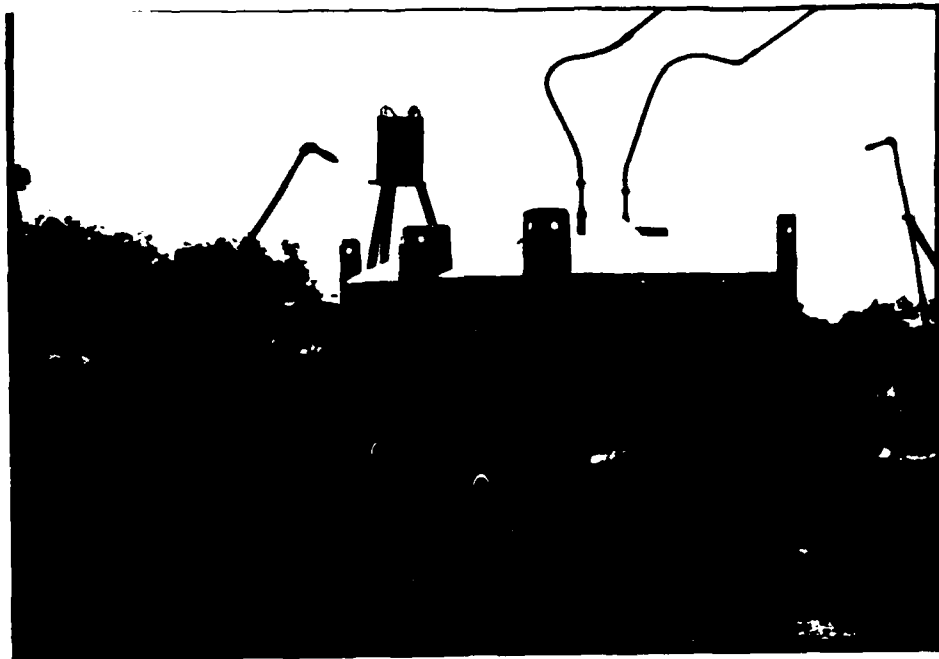


FIGURE 19a. Before Fire

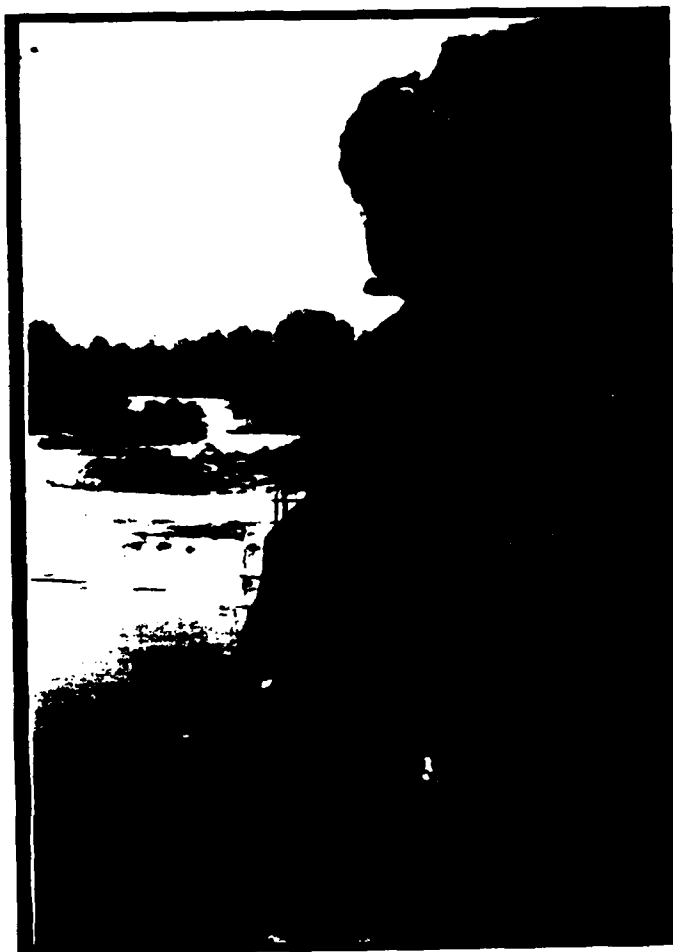


FIGURE 19b. During Fire

FIGURE 19. TYPICAL TANK INTERACTION TESTS



FIGURE 19c. After Fire

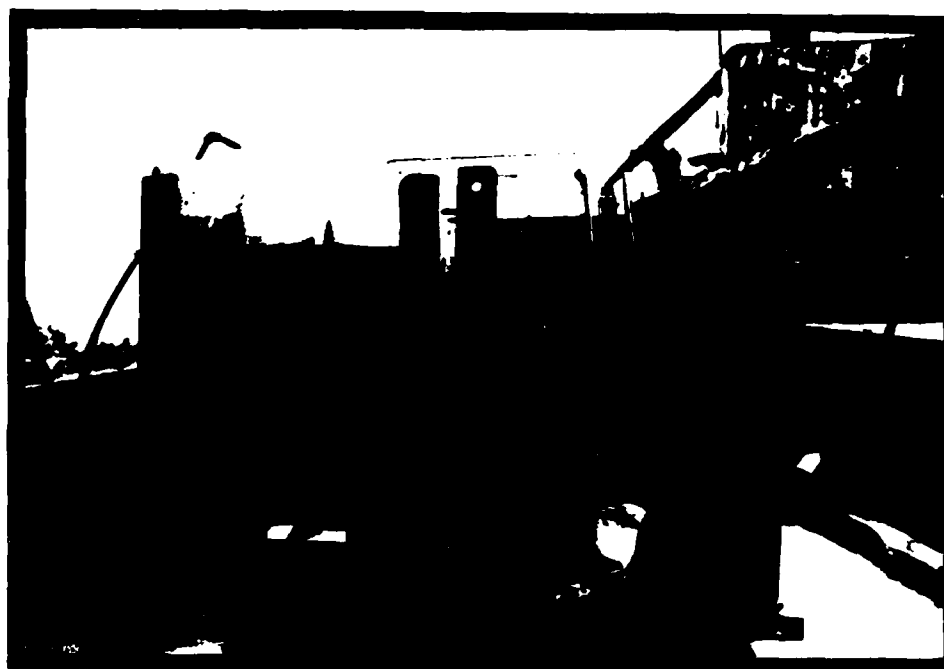


FIGURE 19d. After Fire

FIGURE 19. TYPICAL TANK INTERACTION TESTS (cont'd)

4.0 DISCUSSION

4.1 TIME TO FAILURE FOR POLYETHYLENE TANKS

The fire endurance for six single tanks was evaluated using diesel fuel and alcohol as flammable fuel contents. All six tanks were 320 gallons in capacity. The results are summarized in Table Ia.

Table I
a. Single Polyethylene Tanks

Test #	Fuel Contents	Fire Size	Failure Time
			(min:sec)
16	Diesel	100 ft ²	6'25"
17	Diesel	100 ft ²	4'25"
19	Alcohol	100 ft ²	5'00"
22	Alcohol	4 ft ²	5'18"
23	Diesel	4 ft ²	4'46"
25	Diesel	4 ft ²	5'44"

The fire endurance for side-by-side polyethylene tanks was also evaluated. The results are summarized in Table Ib and indicate a delay time of approximately three minutes between the time at which the first tank failed and the time at which the second tank failed.

Table I
b. Side-by-Side Polyethylene Tanks

Test #	Fuel Contents	Fire Size	Failure Time	
			Inboard (min:sec)	Outboard (min:sec)
26	Alcohol	4 ft ²	5'12"	8'10"
27	Diesel	4 ft ²	5'10"	8'20"
29	Diesel	4 ft ²	7'30"	---

Based on these results, the average time to failure is 316 seconds for a single tank subjected to widely differing fire exposures. The 25% spread in the data is probably within the range of experimental heating conditions resulting from such things as wind variations. No significant correlation is present between the differences in time to failure and the fuel volatility. The fact that the time to failure is independent of the size of the exposure fire suggests that there is a common underlying mechanism which is responsible for the collapse of the tank bottom. Therefore an engineering analysis was made to predict time of tank collapse. The analysis assumes that a model in which thermal heating of the tank walls softens the wall reducing its mechanical strength. The model assumes that the heat from the exposure fire is constant over time and can be described by a solution of the general one-dimensional heat-conduction equation using an unsteady-state heat-transfer analysis (5). The solution for the case involving constant heat flux into the surface is given by the following equation.

$$T-T_i = \frac{2q_0\sqrt{\alpha\tau/\pi}}{kA} \exp\left(-\frac{x^2}{4\alpha\tau}\right) - \frac{q_0x}{kA} \left(1 - \operatorname{erf} \frac{x}{2\sqrt{\alpha\tau}}\right)$$

where $T-T_i$ is the temperature change after
time τ and at a depth x
 q_0 is the incident heat flux
 α is the Thermal Diffusivity
 k is the Thermal Conductivity
 A is the area

For these calculations a rate of heating of 1.2 watts/cm² was used for the incident flux. This value was derived from an analysis of the rate of temperature rise for a steel tank exposed to a four square foot fire. Since the thermal conductivity of the steel is high, it can be assumed that the rate of rise of the liquid contents can be used as a measure of the effective incident heat flux at the tank surface. In effect, the tank functions as a time integrated calorimeter. The value of 1.2 watts/cm² was obtained using data from Test 14 for ethyl alcohol and physical data (6) shown in Table II.

This solution was programmed to obtain values for the temperature of the polyethylene tank walls as a function of fire exposure time and distance from the absorbing surface. A Vicat temperature of 120°C at the inside surface of the tank wall (9.5mm) was used as a criteria for the onset of tank failure for the tanks tested on this project.

* The Vicat temperature is a physical property of a polymeric material as determined by ASTM D-1525 (7). This property corresponds to the onset of plastic flow and varies from 115° to 125° C for high density polyethylene feed stocks.

Table II
Physical Data for Ethyl Alcohol

Molecular Weight	46.07
Specific Gravity	0.789 grams/cc
Heat Capacity	26.64 cal/mole-°C

Results of this analysis are given in Figure 20. The predicted time to failure for the tanks tested is 380 seconds as compared to the experimental value of 316 seconds. Considering the approximations in estimating the heat input to the tank (1.2 Watts/cm²) the values are in reasonable agreement with experimental results. The shaded area indicates the predicted time to failure for high density polyethylene feed stocks characterized by Vicat temperature from 115° to 125°C. The corresponding predictions for time to failure range from about 330 to 385 seconds.

4.2 CORRELATION BETWEEN POLYETHYLENE WALL THICKNESS AND TIME TO FAILURE

Previous Coast Guard tests (2) provided experimental information on the time to failure for selected polyethylene flammable fuel containers. The containers evaluated were 5, 15, 30, and 55 gallon drums. The minimum thickness of these containers is listed in Table III together with data for the 300 gallon tanks used on this project.

TABLE III
MINIMUM THICKNESS
OF
SELECTED COMMERCIAL POLYETHYLENE CONTAINERS

Size of Container (gallons)	Minimum Wall Thickness (mm)
5	1.27
15	1.90
55	2.54
30	3.2
300	9.5

TIME TO FAILURE OF 300 GALLON POLYETHYLENE TANK

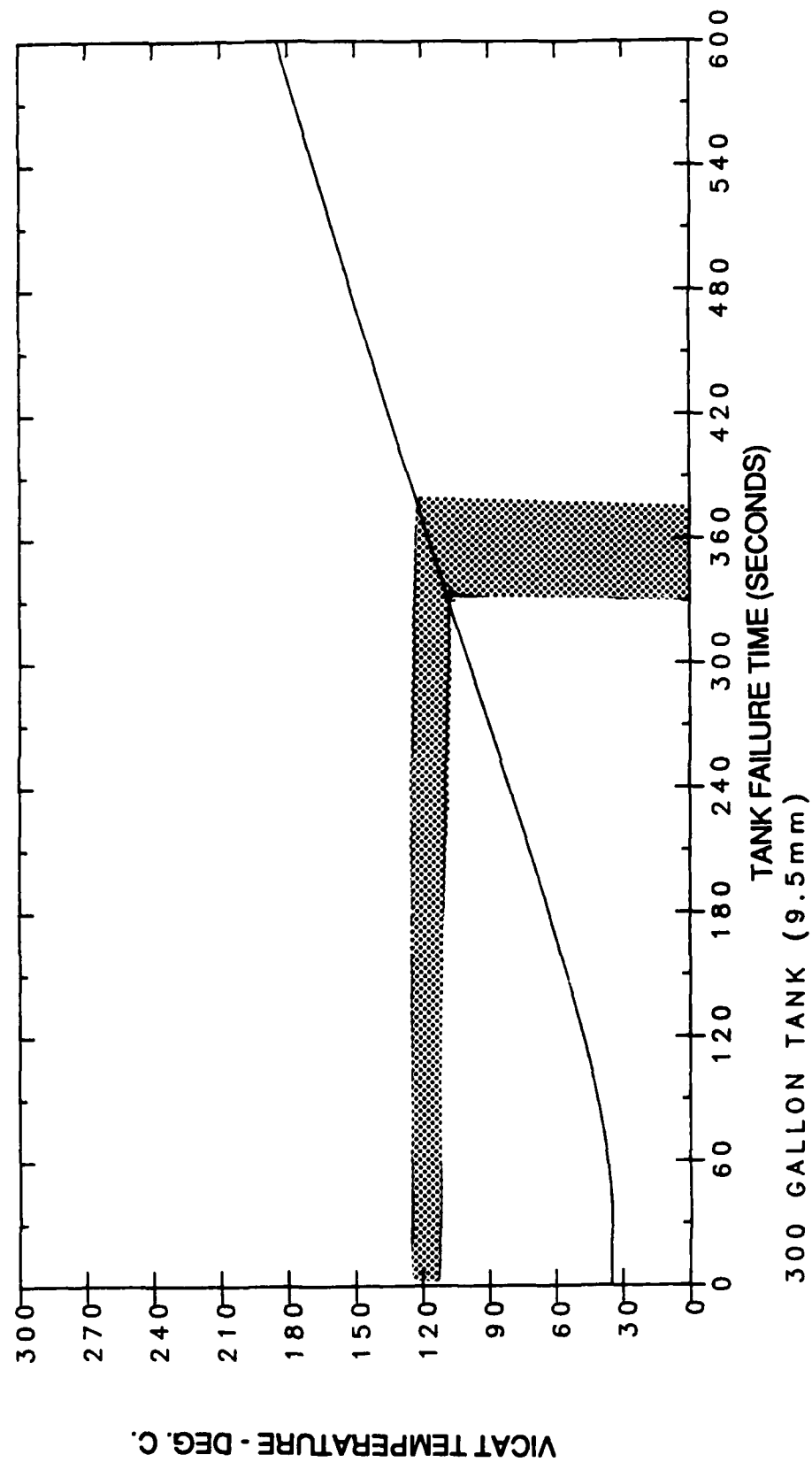


FIGURE 20. Predicted Time for Polyethylene Tank Failure

The analytical calculations described in Section 4.1 were extended to include these containers. The results of these calculations are summarized in Figure 21 and Table IV.

TABLE IV
COMPARISON OF CALCULATED AND EXPERIMENTAL TIME OF FAILURE FOR
SELECTED COMMERCIAL POLYETHYLENE CONTAINERS

Size of Container (gallons)	Time to Failure	
	Calculated (seconds)	Experimental (seconds)
5	60	60
15	75	85
55	95	95
30	115	105
300	380	320

The general agreement between calculated and experimental values suggests that the fire endurance of polyethylene containers is primarily a function of wall thickness. Since the wall thickness of polyethylene containers usually increases with increasing liquid capacity, the fire endurance also increases with size.

4.3 HEAT TRANSFER MECHANISMS

The fact that there was good agreement between the experimental and calculated tank failure times suggests that most of the heat absorbed at the tank surface of the polyethylene tanks is not transferred to the liquid contents but remains in the tank wall. In effect the mass of polyethylene acts as a thermal heat sink for the fire. The experimental data from the thermocouples located in the tank and the pressure transducers monitoring ullage pressure fully support this conclusion. Therefore, the usefulness of pressure relief systems in polyethylene tanks is limited. Failure occurs in about five minutes.

For steel tanks the situation is reversed. For steel tanks the thermoconductivity of the tank walls is high and the heat from the fire is transferred rapidly and efficiently to the liquid contents. The tank contents function as a large heat sink and thereby protect the tank. For long exposures to fire there is a gradual heating of the tank contents with the resultant increase in internal pressure. For volatile liquids this process occurs more rapidly than for less volatile liquids.

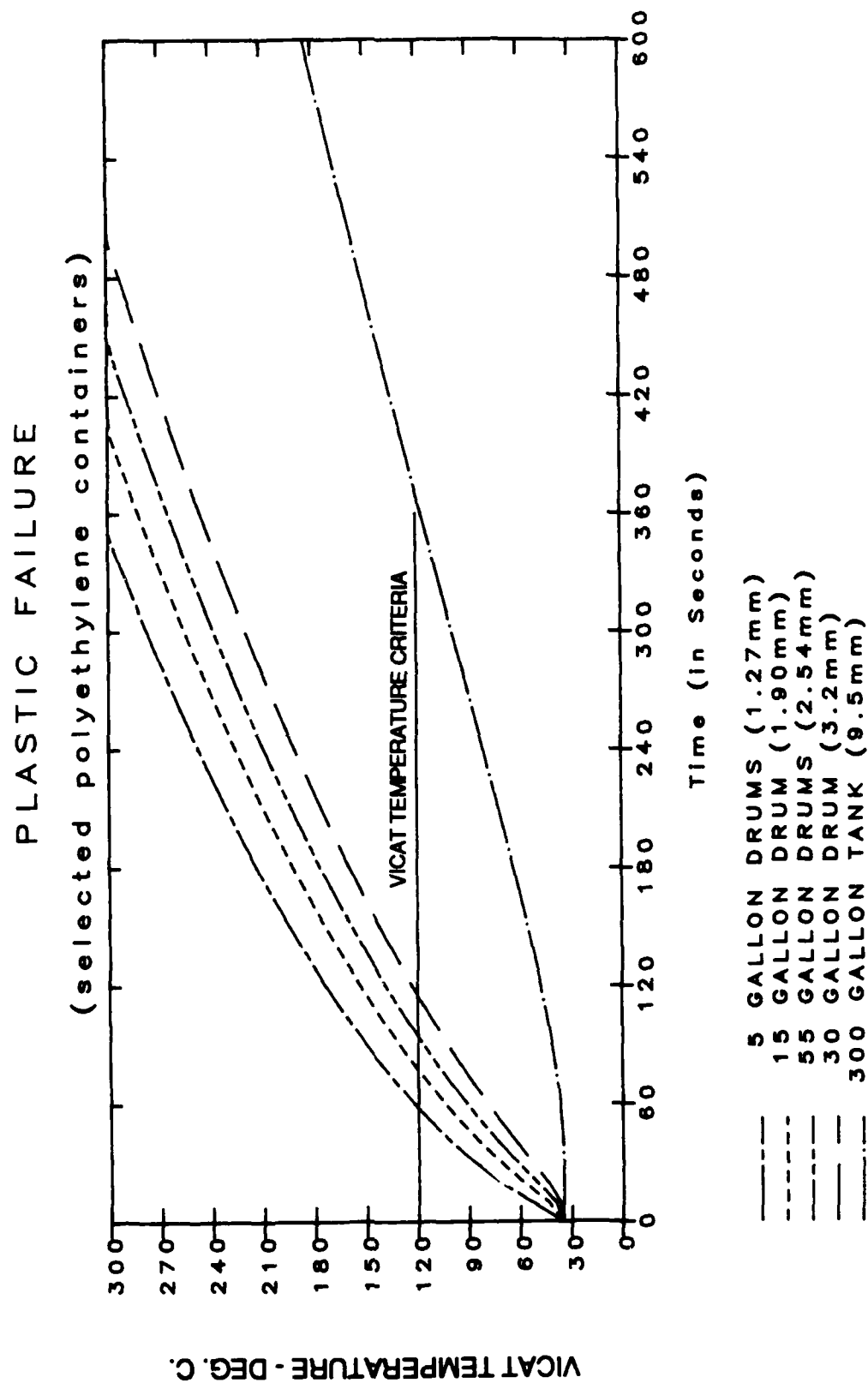


FIGURE 21. Calculated Time to Failure as a Function of Minimum Container Thickness and Temperature

4.4 THE FIRE HAZARD - POLYETHYLENE VS STEELS TANKS

4.4.1 Fire Spread Rate for Polyethylene Tanks

In developing information for a fire hazard assessment an important factor is the estimated rate of fire spread. In order to estimate this factor, it is necessary to assume specific characteristics for the initiating fire exposure and the spatial arrangement of the cargo. For polyethylene tanks it was assumed that the initiating fire was a small 4 ft² fire located directly underneath a polyethylene tank containing flammable fuel. The cargo was assumed to consist of 49 tanks arranged in a square close-packed array. The arrangement is shown in Figure 22. The initiating fire occurs at the center point "S" and spreads successively to the nearest neighbors indicated by X and O in a series of discrete steps.

```

X X X X X X X
X O O O O O X
X O X X X O X
X O X S X O X
X O X X X O X
X O O O O O X
X X X X X X X

```

FIGURE 22. SQUARE CLOSE-PACKED CARGO ARRAY

Using the data from Table Ib for fire spread between adjacent tanks it was assumed that the central tank under which the fire started failed in 8 minutes, and that all the tanks adjacent to it failed three minutes later. Further, it was assumed that this process continued to the outer ring of the array with the same delays. For 300 gallon tanks the total involvement of flammable fuel as a function of time is given in Figure 23.

4.4.2 Estimated Response Time Requirement

4.4.2.1 Polyethylene Tanks

In order to evaluate the potential fire safety hazard for polyethylene tanks, it is necessary to estimate the time needed for the combined operations of detection and damage control team response. For tanks carried in a cargo hold, it is estimated that the detection response time would be a minimum of 3 to 5 minutes, and that the time required for arrival of the fully equipped damage control team would be ten minutes after detection. For deck cargo, it is estimated that the time required for detection would be 5 to 10 minutes; and that the deck foam monitors could be manned within eight minutes after detection. For either case, it would be predicted that the damage control team would be faced with a fire involving a minimum of 2700 gallons of flammable fuel

TANK TESTS

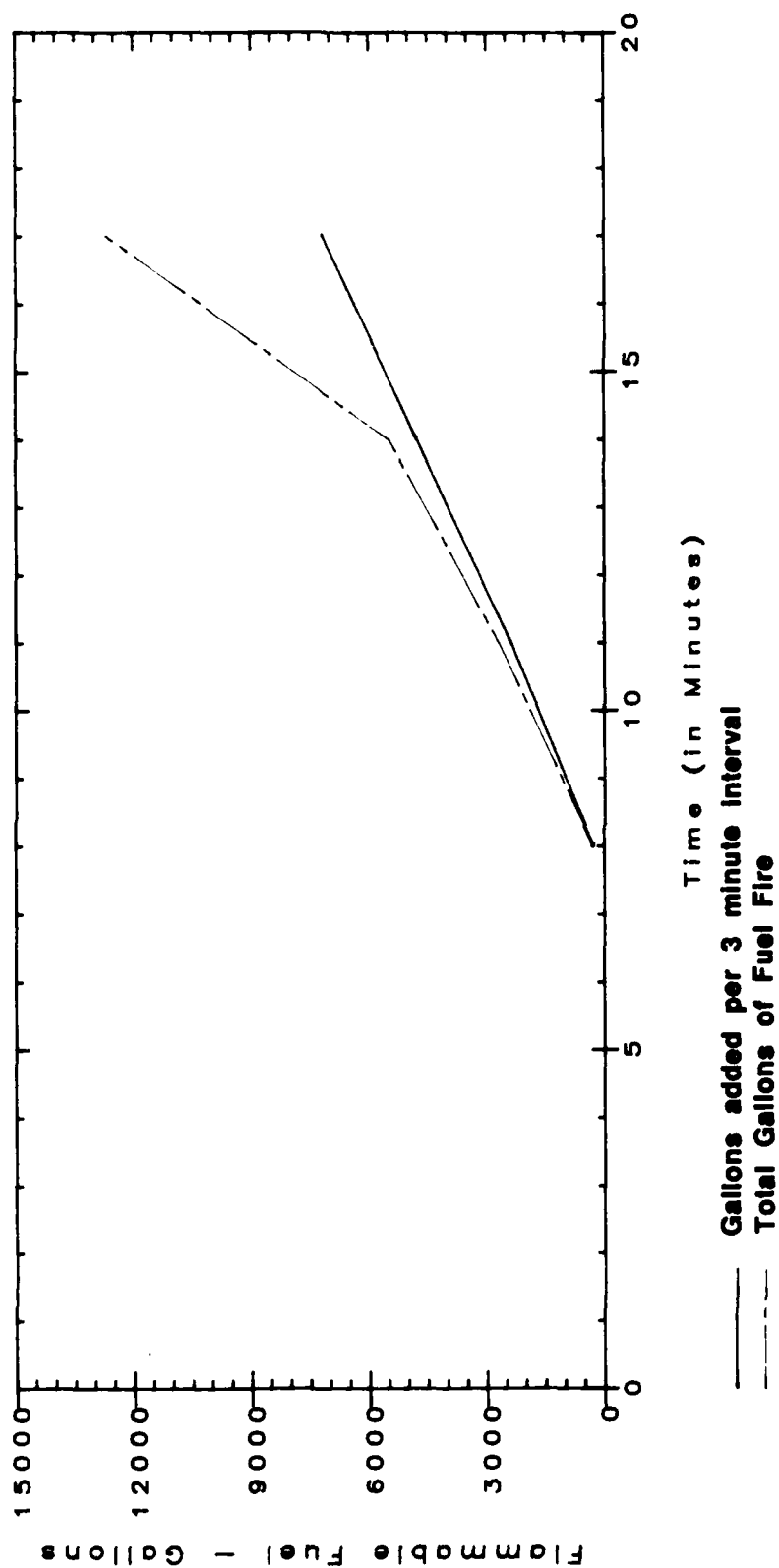


FIGURE 23. Rate of Involvement of Flammable Fuel

at the time of their arrival. Further, unless the team were both well trained and equipped to extinguish liquid fuel fires, it is estimated that the ship would be involved in a 10,000 gallon fire within twenty minutes.

4.4.2.2 Steel Tanks

For steel tanks, as reported in Sections 3.1.2 and 3.2.2, the tank walls did not fail. When exposed to large fires, the vent release melts and volatile fuel vapors burn as they exit the tank. Experimental times for the development of a plume fire are summarized in Table V. A worse case scenario involves exposure to a small scale fire for an extended time period coupled with a faulty pressure activated vent release. For a typical liquid such as ethyl alcohol, the delay between the start of the initiating fire and the blow-off of the high pressure fuel vapors (25 - 30 psig) was about 45 minutes. The major hazard that is involved is the extended plume fire. For this scenario to take place, it would be necessary to assume that effective fire fighting action could not take place within a 45 minute time after the start of the initiating fire. This is unlikely. The maximum quantity of fuel that would be involved is estimated to be between 250 - 300 gallons. Since damage control personnel equipped with hose streams could be directed to cool the tanks, there is a relatively low hazard compared to the large volume liquid fuel fire expected from the polyethylene tanks.

Previous Coast Guard fire tests concluded that polyethylene drums were less hazardous than steel drums when exposed to fire. These tests used steel drums which were not fitted with pressure relief closures. As a result, the steel drums developed pressures which exceeded the burst strength of the containers. The major safety hazard associated with these drums resulted from the catastrophic nature of the bursting process. The IBC tanks used on this project were required by DOT regulations to have relief vents. These vents are actuated by either high pressures or high temperatures. Although these relief devices did not function properly on all these tests, they did function effectively before major structural damage occurred. Therefore, the severe safety hazards which occurred during the fire exposure on the steel drum tests did not occur for commercial steel IBC tanks.

Consideration of these factors indicates that the use of polyethylene containers would result in an unacceptable risk to ship safety and that minimal risks would be incurred from flammable fuels in steel tanks provided the steel tanks are equipped with reliable pressure/temperature relief vents.

TABLE V
EXPERIMENTAL TIMES FOR DEVELOPMENT
OF
PLUME FIRES IN STEEL TANKS

Test Number	Fire Size	Tank Contents	Structural Damage	Start of Plume Fire (Minutes)
5	Large	Diesel	None	22
6	Large	Diesel	None	25
7	Large	Ethyl Alcohol	None	6
8	Large	Ethyl Alcohol	None	6
10	Small	Diesel	Uncapped Valve Leak	No Plume
11	Small	Diesel	None	No Plume
13	Small	Ethyl Alcohol	None	39
14	Small	Ethyl Alcohol	None	84
15	Small	Ethyl Alcohol	None	141

5.0 CONCLUSIONS

- 0 Polyethylene tanks containing flammable fuels are more hazardous than steel tanks. These hazards result from the release of large quantities of flammable contents in a short time.
- 0 The most common failure mode for polyethylene tanks involves thermoplastic softening followed by structural collapse.
- 0 Commercial polyethylene IBC tanks may fail and release their contents within 6 minutes when exposed to fire.
- 0 Failure times for polyethylene tanks are independent of fuel volatility for the range of fuels investigated.
- 0 Failure times for polyethylene tanks are independent of fire size when the fire is in direct contact with the tank.
- 0 Failure of an adjacent polyethylene tank may occur within three minutes after the rupture of the initial tank.
- 0 Extinguishment of flammable fuel fires in thermoplastic polyethylene tanks is difficult because of the trapping of flammable fuel in pockets formed by the folding of the tank walls.
- 0 The time to failure for polyethylene tanks is primarily dependent on tank wall thickness not tank capacity.

REFERENCES

1. Title 49, Code of Federal Regulations, Part 178.19: Specification 34.
- 2a. Report No. CG-D-116-76, "Fire Exposure Tests of Polyethylene and Fifty-Five Gallon Steel Drums Loaded with Flammable Liquids Phase I, September 1976, ADA 043 803, NTIS.
- b. Report No. CG-D-86-77, "Fire Exposure Tests of Polyethylene and Fifty-Five Steel Drums Loaded with Flammable Liquids Phase II", August 1977, Available NTIS.
3. DOT Exemption DOT-E 8225 (6 August 1982). U.S. Coast Guard Headquarters. Office of Marine Safety, Security and Environmental Protection, G-MTH-3, Washington, D.C.
4. DOT Exemption DOT-E 8570 (6 May 1982). U.S. Coast Guard Headquarters. Office of Marine Safety, Security and Environmental Protection, G-MTH-3, Washington, D.C.
5. Holman, J.P.; "Heat Transfer", 5th ed., McGraw-Hill Book Co., New York, 1981, pp. 116-117.
6. Reid, R.C., and Sherwood, "The Properties of Gases and Liquids", McGraw Hill (1968), pp. 283.
7. CRC Handbook of Materials Science, Volume III, Nonmetallic Materials and Applications, Ed. Charles T. Lynch, CRC Press Inc., (1975).

APPENDIX A

INSTRUMENTATION FOR TEST SERIES 43A1

CHANNEL NUMBER	DESCRIPTION
1	<p>INSTRUMENT: WIND DIRECTION SERIAL NUMBER: 04401A-D CLASS: IW3 MANUFACTURER: R.M. YOUNG CO. MODEL: 04401A VOLTS: 0.00 to 1.00000 OUTPUT/RANGE: 0.0 to 360.00 DEGREES AZIMUTH LOCATION: North at 0 degrees. REMARKS: ----- ACTUATOR: 41 Time Date Generator Close on test start, Open on test end.</p>
2	<p>INSTRUMENT: WIND INTENSITY SERIAL NUMBER: 04401A-I CLASS: IW3 MANUFACTURER: R.M. YOUNG CO. MODEL: 04401A VOLTS: 0.00 to 1.00000 OUTPUT/RANGE: 0.00 to 100.00 MPH LOCATION: Locate on main deck about 100 ft from 100 ft2 fire pit. REMARKS: -----</p>
3	<p>INSTRUMENT: LINE VOLTAGE SERIAL NUMBER: 45601-1 CLASS IO8 MANUFACTURER: ROCHESTER INSTRUMENT SYSTEMS MODEL: SC-1300-U1 VOLTS: 1.00 to 5.00000 OUTPUT/RANGE: 0.00 to 150.00 VAC LOCATION: Instrumentation trailer REMARKS: -----</p>
4	<p>INSTRUMENT: LINE FREQUENCY SERIAL NUMBER: 45601-2 CLASS: IO8 MANUFACTURER: ROCHESTER INSTRUMENT SYSTEMS MODEL: FFX-1-60 VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 50.00 to 65.00 CPS LOCATION: Instrumentation trailer REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
5	<p>INSTRUMENT: CO2 INFRARED SERIAL NUMBER: 34062 CLASS: IG2 MANUFACTURER: MINE SAFETY APPLIANCE CO. MODEL: LIRA 303 VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 100.00 % LOCATION: Line at top center of dump tank 1/2 inch from inside wall REMARKS:</p>
6	<p>INSTRUMENT: CO2 INFRARED SERIAL NUMBER: 34063 CLASS: IG2 MANUFACTURER: MINE SAFETY APPLIANCE CO. MODEL: LIRA 303 VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 25.00 % LOCATION: 12 inches from deck on outside of dump tank REMARKS:</p>
7	<p>INSTRUMENT: CO2 INFRARED SERIAL NUMBER: 34064 CLASS: IG2 MANUFACTURER: MINE SAFETY APPLIANCE CO. MODEL: LIRA 303 VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 25.00 % LOCATION: 12 inches from deck on outside of dump tank REMARKS:</p>
8	<p>INSTRUMENT: CO2 INFRARED SERIAL NUMBER: 34065 CLASS: IG2 MANUFACTURER: MINE SAFETY APPLIANCE CO. MODEL: LIRA 303 VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 25.00 % LOCATION: REMARKS: Flexible line 100 ft to monitor areas as "rover" ACTUATOR: 44 CO2 alarm Close when ch #8 >= 3%</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
9	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84387 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 tank pressure REMARKS:</p>
10	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84388 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure at main valve REMARKS:</p>
11	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84389 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. SERIAL NUMBER: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure at entrance to reducer section REMARKS:</p>
12	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84390 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure after reducer section REMARKS:</p>
13	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84391 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure Nozzle #1 REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
14	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84392 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure Nozzle #2 REMARKS:
15	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84393 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure Nozzle #3 REMARKS:
16	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84394 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: CO2 line pressure Nozzle #4 REMARKS:
17	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84396 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: Test Tank #2 REMARKS: See channel 63
18	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 98223 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 100.00 PSIG LOCATION: Test tank #2 REMARKS: See channel 64

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
19	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 98221 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 100.00 PSIG LOCATION: Spare Channel REMARKS:
20	INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 98222 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS, INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 100.00 PSIG LOCATION: Spare Channel REMARKS:
21	INSTRUMENT: RADIOMETER-150 SERIAL NUMBER: 219854 CLASS: IO2 MANUFACTURER: MEDTHERM CORPORATION MODEL: 64P-15-24T VOLTS: 0.00 to 0.01520 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Spare Channel REMARKS:
22	INSTRUMENT: RADIOMETER-60 SERIAL NUMBER: 1023801 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00990 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Spare Channel REMARKS:
23	INSTRUMENT: RADIOMETER-60 SERIAL NUMBER: 1023804 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00958 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Below test tank fwd REMARKS: Mount 1 inch below tank- pointing down

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
24	<p>INSTRUMENT: RADIOMETER-60 SERIAL NUMBER: 125842 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00710 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Below test tank aft REMARKS: Mount 1 inch below tank- pointing down</p>
25	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 10238014 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.01206 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Spare channel REMARKS:</p>
26	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 10238011 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.01060 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Spare Channel REMARKS:</p>
27	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 10238012 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00935 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Below test tank fwd REMARKS: Mount 1 inch below tank- pointing down</p>
28	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 10238013 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.01210 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Below test tank aft REMARKS: Mount 1 inch below tank- pointing down</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
29	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #1 REMARKS: Air line 15 deg. radiometer</p>
30	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #2 REMARKS: Air line 15 deg. radiometer</p>
31	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #3 REMARKS: Air line 15 deg. radiometer</p>
32	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #4 REMARKS: Air line 15 deg. radiometer</p>
33	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Radiometer 125841 REMARKS: Monitor cooling water Channel 23</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
34	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Radiometer 125842 REMARKS: Monitor cooling water Channel 24</p>
35	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Calorimeter 10238012 REMARKS: Monitor cooling water Channel 27</p>
36	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Calorimeter 10238013 REMARKS: Monitor cooling water Channel 28</p>
37	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #1 REMARKS:</p>
38	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #2 REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
39	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #3 REMARKS:</p>
40	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #4 REMARKS:</p>
41	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: In center of tank REMARKS: TC #1 In-Tank</p>
42	<p>THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: 1 inch from top of tank along vertical center line REMARKS: TC #2 In-Tank</p>
43	<p>THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: 1 inch from bottom of tank along vertical center line REMARKS: TC #3 In-Tank</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
44	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: 1 inch from left-hand side of tank along horizontal center line REMARKS: TC #4 In-Tank</p>
45	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: 1 inch from right-hand side of tank along horizontal center line REMARKS: TC #5 In-Tank</p>
46	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Halfway between TC #5 and TC #1 REMARKS: TC #6 In-Tank</p>
47	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Halfway between TC #4 and TC #1 REMARKS: TC #7 In-Tank</p>
48	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Halfway between TC #2 and TC #1 REMARKS: TC #8 In-Tank</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
49	<p>INSTRUMENT: #1WEIGHT IND 4 CELLS SERIAL NUMBER: 1520 CLASS: IO7 MANUFACTURER: B.L.H. ELECTRONICS MODEL: 450 ASW VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 20000.00 LBS. LOCATION: CO2 tank REMARKS: Cardox tank</p>
50	<p>INSTRUMENT: #2WEIGHT IND 1 CELL SERIAL NUMBER: 3310 CLASS: IO7 MANUFACTURER: B.L.H. ELECTRONICS MODEL: 450A VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 5.00 LBS. LOCATION: Test tank REMARKS: See Channel 107</p>
51	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 84395 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 500.00 PSIG LOCATION: Ullage on tank REMARKS: See Channel 61</p>
52	<p>INSTRUMENT: PRESSURE TRANSDUCER SERIAL NUMBER: 98220 CLASS: IO3 MANUFACTURER: SETRA SYSTEMS INC. MODEL: 205-2 VOLTS: 0.00 to 5.00000 OUTPUT/RANGE: 0.00 to 100.00 PSIG LOCATION: Ullage on tank REMARKS: See Channel 62</p>
53	<p>INSTRUMENT: RADIOMETER-60 SERIAL NUMBER: 92891 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00950 OUTPUT/RANGE: 0.00 to 20.00 BTU/SQFT/SEC. LOCATION: Area #1 In-Fire See Channel 65 REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
54	<p>INSTRUMENT: RADIOMETER-150 SERIAL NUMBER: 219851 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: 64P-15-24T VOLTS: 0.00 to 0.01440 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #2 In-Fire See Channel 66 REMARKS:</p>
55	<p>INSTRUMENT: RADIOMETER-150 SERIAL NUMBER: 219852 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: 64P-15-24T VOLTS: 0.00 to 0.01510 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #3 In-Fire See Channel 67 REMARKS: See Part I, Task II</p>
56	<p>INSTRUMENT: RADIOMETER-150 SERIAL NUMBER: 219853 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: 64P-15-24T VOLTS: 0.00 to 0.01570 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #4 In-Fire See Channel 68 REMARKS:</p>
57	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 10238016 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: 64-15-20-6MGO VOLTS: 0.00 to 0.01120 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #1 In-Fire See Channel 69 REMARKS: May be operating at 18 Btu/ft2 sec</p>
58	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 1023807 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.01160 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #2 In-Fire See Channel 70 REMARKS: May be operating at 18 Btu/ft2 sec</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
59	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 92894 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00980 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #3 In-Fire See Channel 71 REMARKS: May be operating at 18 Btu/ft2 sec</p>
60	<p>INSTRUMENT: CALORIMETER SERIAL NUMBER: 1023809 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.01015 OUTPUT/RANGE: 0.00 to 15.00 BTU/SQFT/SEC. LOCATION: Area #4 In-Fire See Channel 72 REMARKS: May be operating at 18 Btu/ft2 sec</p>
61	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Pressure transducers REMARKS: Channel 51</p>
62	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Pressure transducers REMARKS: Channel 52</p>
63	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Pressure transducers REMARKS: Channel 17, Tank #2</p>
64	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Pressure transducers REMARKS: Channel 18, Tank #2</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER

DESCRIPTION

65	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #1 Water Line See channel 53 REMARKS: Attach to output water line for Radiometer 98891</p>
66	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #2 Water Line See Channel 54 REMARKS: Attach to output water line for Radiometer 219851</p>
67	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #3 Water Line See Channel 55 REMARKS: Attach to output water line for Radiometer 219852</p>
68	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #4 Water Line See Channel 56 REMARKS: Attach to output water line for Radiometer 219853</p>
69	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #1 Water Line See Channel 57 REMARKS: Attach to output water line for Calorimeter 92892</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
70	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #2 Water Line See Channel 58 REMARKS: Attach to output water line for Calorimeter 92893</p>
71	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #3 Water Line See Channel 59 REMARKS: Attach to output water line for Calorimeter 92894</p>
72	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #4 Water Line See Channel 60 REMARKS: Attach to output water line for Calorimeter 92895</p>
73	<p>INSTRUMENT: RADIOMETER-15 SERIAL NUMBER: 613862 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: TGRW2-15-804 VOLTS: 0.00 to 0.00362 OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC. LOCATION: Area #1 See Channel 100 REMARKS: +/- 5 deg. horizontal view</p>
74	<p>INSTRUMENT: RADIOMETER-15 SERIAL NUMBER: 613863 CLASS: IO2 MANUFACTURER: MODEL: VOLTS: 0.00 to 0.00325 OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC. LOCATION: Area #2 See Channel 101 REMARKS: +/- 5 deg. horizontal view</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
75	<p>INSTRUMENT: RADIOMETER-15 SERIAL NUMBER: 613864 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: TGRW-15-804 VOLTS: 0.00 to 0.00323 OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC. LOCATION: Area #3 See Channel 102 REMARKS: +/- 5 deg. horizontal view</p>
76	<p>INSTRUMENT: RADIOMETER-15 SERIAL NUMBER: 613861 CLASS: IO2 MANUFACTURER: MEDTHERM CORP. MODEL: TGRW-15-804 VOLTS: 0.00 to 0.00320 OUTPUT/RANGE: 0.00 to 2.00 BTU/SQFT/SEC. LOCATION: Area #4 See Channel 103 REMARKS: +/- 5 deg. horizontal view</p>
77	<p>INSTRUMENT: POSITION INDICATOR SERIAL NUMBER: DUM-5 CLASS: IO8 MANUFACTURER: MODEL: VOLTS: 0.00 to 10.00000 OUTPUT/RANGE: 0.00 to 15.00 FT. LOCATION: Area #1 REMARKS:</p>
78	<p>INSTRUMENT: POSITION INDICATOR SERIAL NUMBER: DUM-6 CLASS: IO8 MANUFACTURER: MODEL: VOLTS: 0.00 to 10.00000 OUTPUT/RANGE: 0.00 to 15.00 FT. LOCATION: Area #2 REMARKS:</p>
79	<p>INSTRUMENT: POSITION INDICATOR SERIAL NUMBER: DUM-7 CLASS: IO8 MANUFACTURER: MODEL: VOLTS: 0.00 to 10.00000 OUTPUT/RANGE: 0.00 to 15.00 FT. LOCATION: Area #3 REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
80	<p>INSTRUMENT: POSITION INDICATOR SERIAL NUMBER: DUM-8 CLASS: IO8 MANUFACTURER: MODEL: VOLTS: 0.00 to 10.00000 OUTPUT/RANGE: 0.00 to 15.00 FT. LOCATION: Area #4 REMARKS:</p>
81	<p>INSTRUMENT: HYDROCARBON FLAME SERIAL NUMBER: 1002592 CLASS: IG7 MANUFACTURER: BECKMAN INSTRUMENTS MODEL: 400 VOLTS: 0.00 to 1.00000 OUTPUT/RANGE: 0.00 to 40000.00 PPM LOCATION: Below fire deck REMARKS: Use to trigger alarm at 1% actuator => 10000 PPM ACTUATOR: 42 Hydrocarbon Alarm Close when ch #81 >= 10000 PPM</p>
82	<p>INSTRUMENT: HYDROCARBON FLAME SERIAL NUMBER: 1002593 CLASS: IG7 MANUFACTURER: BECKMAN INSTRUMENTS MODEL: 400 VOLTS: 0.00 to 1.00000 OUTPUT/RANGE: 0.00 to 40000.00 PPM LOCATION: Rover pickup line REMARKS: Use to trigger alarm at 1% actuator => 10000 PPM ACTUATOR: 43 Hydrocarbon Alarm Close when ch #82 >= 10000 PPM</p>
83	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare channel REMARKS:</p>
84	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare channel REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
85	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Cooling water REMARKS: Channel 23 radiometer</p>
86	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Cooling water REMARKS: Channel 24 radiometer</p>
87	<p>INSTRUMENT: #3WEIGHT IND 1 CELL SERIAL NUMBER: 3311 CLASS: IO7 MANUFACTURER: B.L.H. ELECTRONICS MODEL: 450A VOLTS: 0.00 to 0.10000 OUTPUT/RANGE: 0.00 to 5000.00 LBS. LOCATION: Deck cell #1 REMARKS: See channel 104</p>
88	<p>INSTRUMENT: #4WEIGHT IND 1 CELL SERIAL NUMBER: 3590 CLASS: IO7 VOLTS: 0.00 to 0.10000 MANUFACTURER: B.L.H. ELECTRONICS MODEL: 450A OUTPUT/RANGE: 0.00 to 5000.00 LBS. LOCATION: Deck cell #2 REMARKS: See channel 105</p>
89	<p>INSTRUMENT: #5WEIGHT IND 1 CELL SERIAL NUMBER: 3389 CLASS: IO7 VOLTS: 0.00 to 0.10000 MANUFACTURER: B.L.H. ELECTRONICS MODEL: 450A OUTPUT/RANGE: 0.00 to 5000.00 LBS. LOCATION: Deck cell #3 REMARKS: See channel 106</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
90	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #1 REMARKS: Test tank #2 (Channel 41)</p>
91	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #2 REMARKS: Test tank #2 (Channel 42)</p>
92	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #3 REMARKS: Test tank #2 (Channel 43)</p>
93	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #4 REMARKS: Test tank #2 (Channel 44)</p>
94	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #5 REMARKS: Test tank #2 (Channel 45)</p>
95	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #6 REMARKS: Test tank #2 (Channel 46)</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
96	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #7 REMARKS: Test tank #2 (Channel 47)</p>
97	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/16IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Thermocouple #8 REMARKS: Test tank #2 (Channel 48)</p>
98	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Cooling water REMARKS: Channel 27 calorimeter</p>
99	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Cooling water REMARKS: Channel 28 calorimeter</p>
100	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #1 REMARKS: 15 deg. view radiometer</p>
101	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #2 REMARKS: 15 deg. view radiometer</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
102	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #3 REMARKS: 15 deg. view radiometer</p>
103	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Area #4 REMARKS: 15 deg. view radiometer</p>
104	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Deck #1 REMARKS: Load Cell</p>
105	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Deck #2 REMARKS: Load Cell</p>
106	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Deck #3 REMARKS: Load Cell</p>
107	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Overhead REMARKS: Load Cell</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
108	<p>INSTRUMENT: T/C REFERENCE JUNCTION SERIAL NUMBER: TC1 CLASS: IO5 MANUFACTURER: OMEGA ENGINEERING MODEL: OMEGA-CJ VOLTS: 0.00 to 0.00200 OUTPUT/RANGE: 0.00 to 50.00 DEG. C. LOCATION: Ch# 29,30,31,32,33,34,35,36,37,38, 39,40,65,66,67, 68,69,70,71,72 REMARKS:</p>
109	<p>INSTRUMENT: T/C REFERENCE JUNCTION SERIAL NUMBER: TC2 CLASS: IO5 MANUFACTURER: OMEGA ENGINEERING MODEL: OMEGA-CJ VOLTS: 0.00 to 0.00200 OUTPUT/RANGE: 0.00 to 50.00 DEG. C. LOCATION: Ch# 41,42,43,44,45,46,47,48, 61,62,63,64,115,116, 117,118,119 REMARKS:</p>
110	<p>INSTRUMENT: T/C REFERENCE JUNCTION SERIAL NUMBER: TC3 CLASS: IO5 MANUFACTURER: OMEGA ENGINEERING MODEL: OMEGA-CJ VOLTS: 0.00 to 0.00200 OUTPUT/RANGE: 0.00 to 50.00 DEG. C. LOCATION: Ch# 86,90-107,111-114 REMARKS:</p>
111	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
112	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER	DESCRIPTION
113	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
114	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
115	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
116	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
117	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>
118	<p>INSTRUMENT: THERMOCOUPLE TYPE K SERIAL NUMBER: K50FT1/8IN CLASS: IO5 MANUFACTURER: THERMO-ELECTRIC CO. VOLTS: 0.00 to 0.04150 OUTPUT/RANGE: 0.00 to 1000.00 DEG. C. LOCATION: Spare REMARKS:</p>

INSTRUMENTATION FOR TEST SERIES 43A1 (cont'd)

CHANNEL NUMBER

DESCRIPTION

119

INSTRUMENT: THERMOCOUPLE TYPE K
SERIAL NUMBER: K50FT1/8IN CLASS: IO5
MANUFACTURER: THERMO-ELECTRIC CO.
VOLTS: 0.00 to 0.04150
OUTPUT/RANGE: 0.00 to 1000.00 DEG. C.
LOCATION: Spare
REMARKS:

THE FOLLOWING ARE SUPPLEMENTARY INSTRUMENTS FOR THE CHANNEL(S)
INDICATED:

0 INSTRUMENT: LOAD CELL
 SERIAL NUMBER: 56825 CLASS: IO7
 MANUFACTURER: B.L.H. ELECTRONICS
 MODEL: U3G1
 VOLTS: 0.00 to 0.03
 OUTPUT/RANGE: 0.00 to 5000.00 LBS.
 LOCATION:
 REMARKS:

0 INSTRUMENT: LOAD CELL
 SERIAL NUMBER: 56905 CLASS: IO7
 MANUFACTURER: B.L.H. ELECTRONICS
 MODEL: U3G1
 VOLTS: 0.00 to 0.03
 OUTPUT/RANGE: 0.00 to 5000.00 LBS.
 LOCATION:
 REMARKS:

0 INSTRUMENT: LOAD CELL
 SERIAL NUMBER: 56906 CLASS: IO7
 MANUFACTURER: B.L.H. ELECTRONICS
 MODEL: U3G1
 VOLTS: 0.00 to 0.03
 OUTPUT/RANGE: 0.00 to 5000.00 LBS.
 LOCATION:
 REMARKS:

0 INSTRUMENT: LOAD CELL
 SERIAL NUMBER: 56980 CLASS: IO7
 MANUFACTURER: B.L.H. ELECTRONICS
 MODEL: U3G1
 VOLTS: 0.00 to 0.03
 OUTPUT/RANGE: 0.00 to 5000.00 LBS.
 LOCATION:
 REMARKS:

0 INSTRUMENT: LOAD CELL
 SERIAL NUMBER: 05198A CLASS: IO7
 MANUFACTURER: B.L.H. ELECTRONICS
 MODEL: U3G1
 VOLTS: 0.00 to 0.03
 OUTPUT/RANGE: 0.00 to 5000.00 LBS.
 LOCATION:
 REMARKS:

0 INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05221A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:

0 INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05263A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:

0 INSTRUMENT: LOAD CELL
SERIAL NUMBER: 05266A CLASS: IO7
MANUFACTURER: B.L.H. ELECTRONICS
MODEL: U3G1
VOLTS: 0.00 to 0.03
OUTPUT/RANGE: 0.00 to 5000.00 LBS.
LOCATION:
REMARKS:

APPENDIX B

TEST DATA

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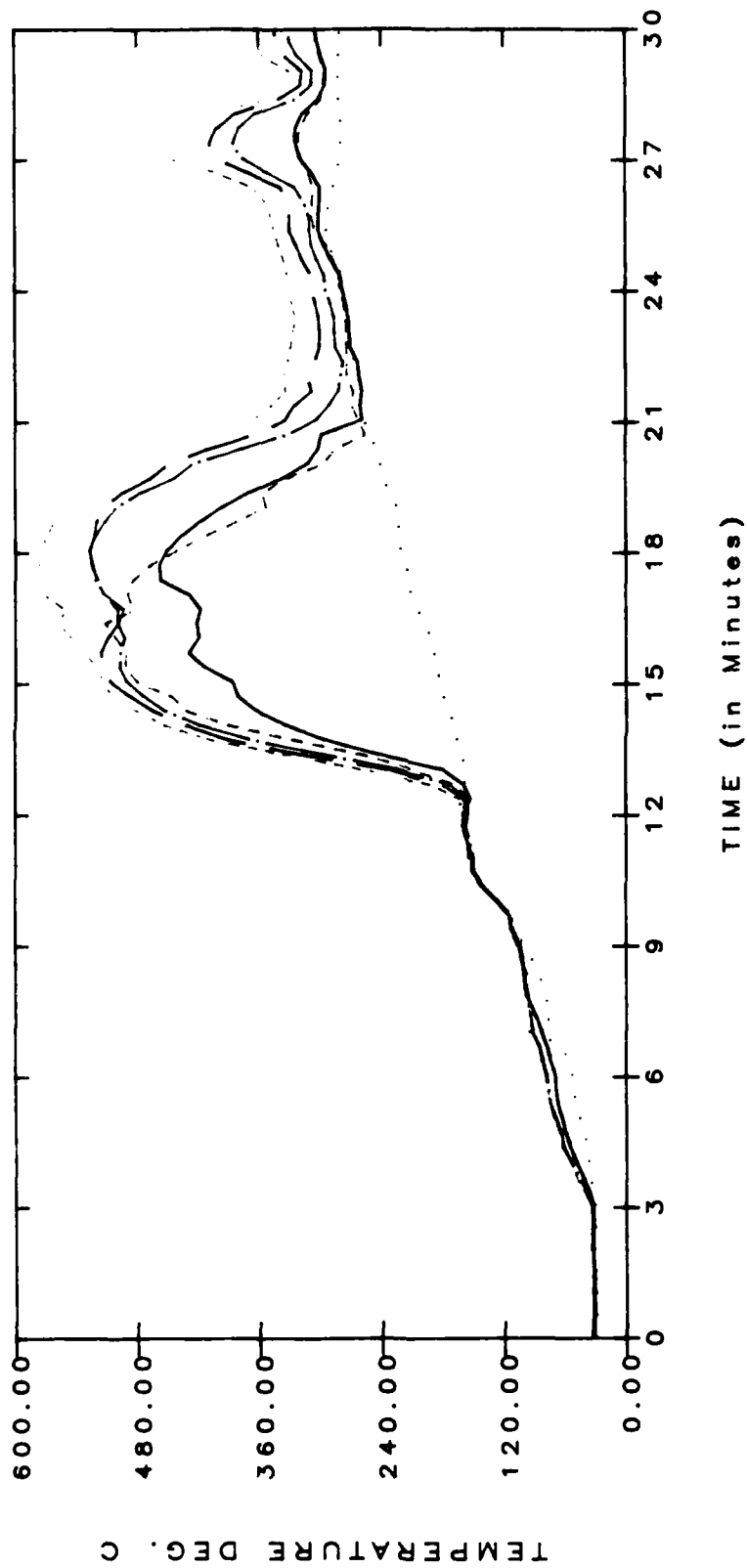
TEST # 5

TYPE OF TANK: STEEL TANK
TANK CONTENTS: # 2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 20 JUNE 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:30	FLAMES AROUND RELIEF VALVE
00:09:18	VALVE APPEARS TO BE VENTING. CONTENTS RUNNING OUT OF TANK TOP
00:22:00	PLUME FIRE
00:28:53	CO2 APPLICATION #1
00:31:10	REKINDLE
00:32:00	CO2 APPLICATION #2
00:34:00	H2O COOL DOWN TANK APPEARS INTACT

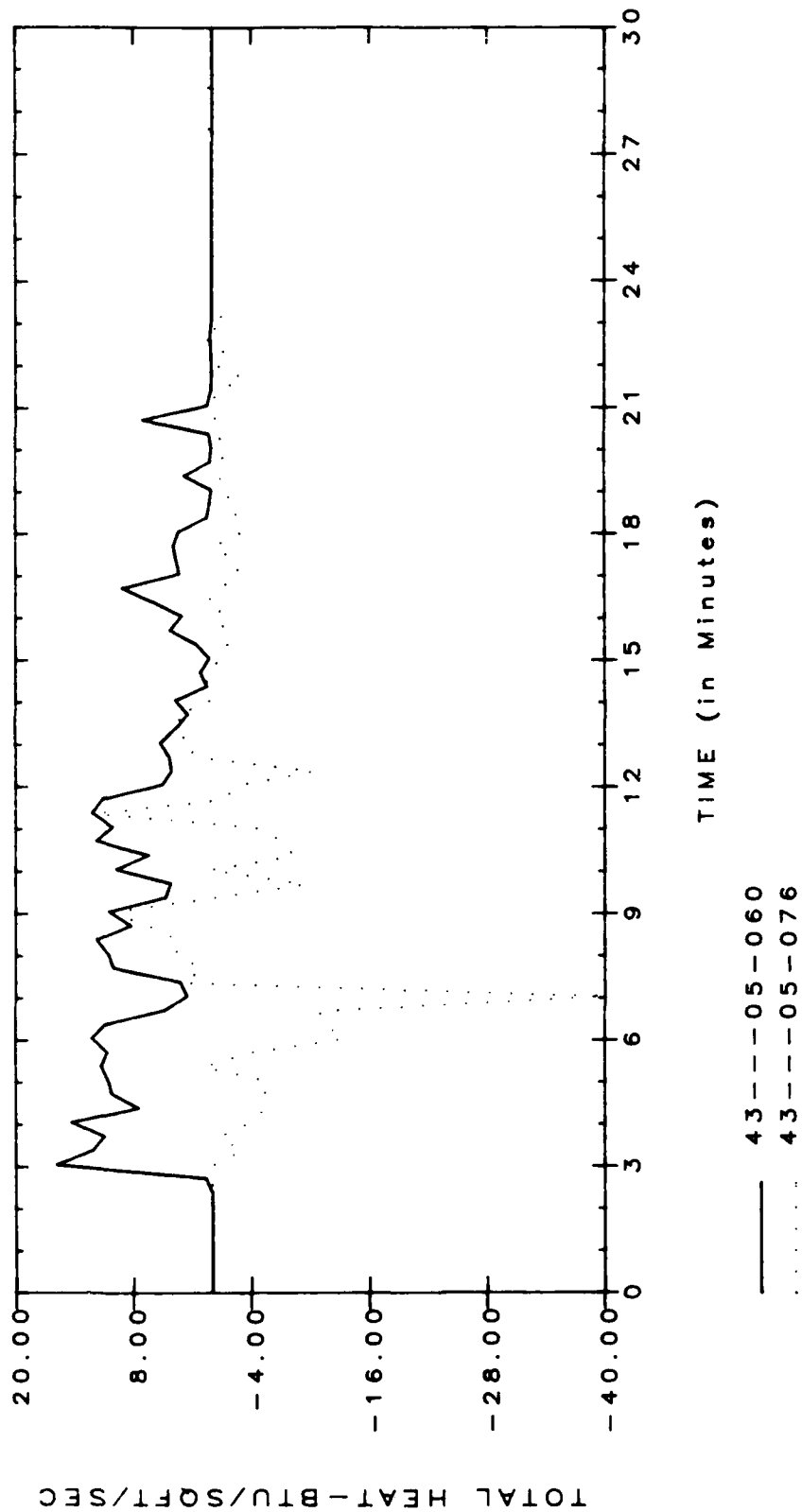
TANK TESTS



43-05-041
 43-05-043
 43-05-045
 43-05-046
 43-05-047
 43-05-048

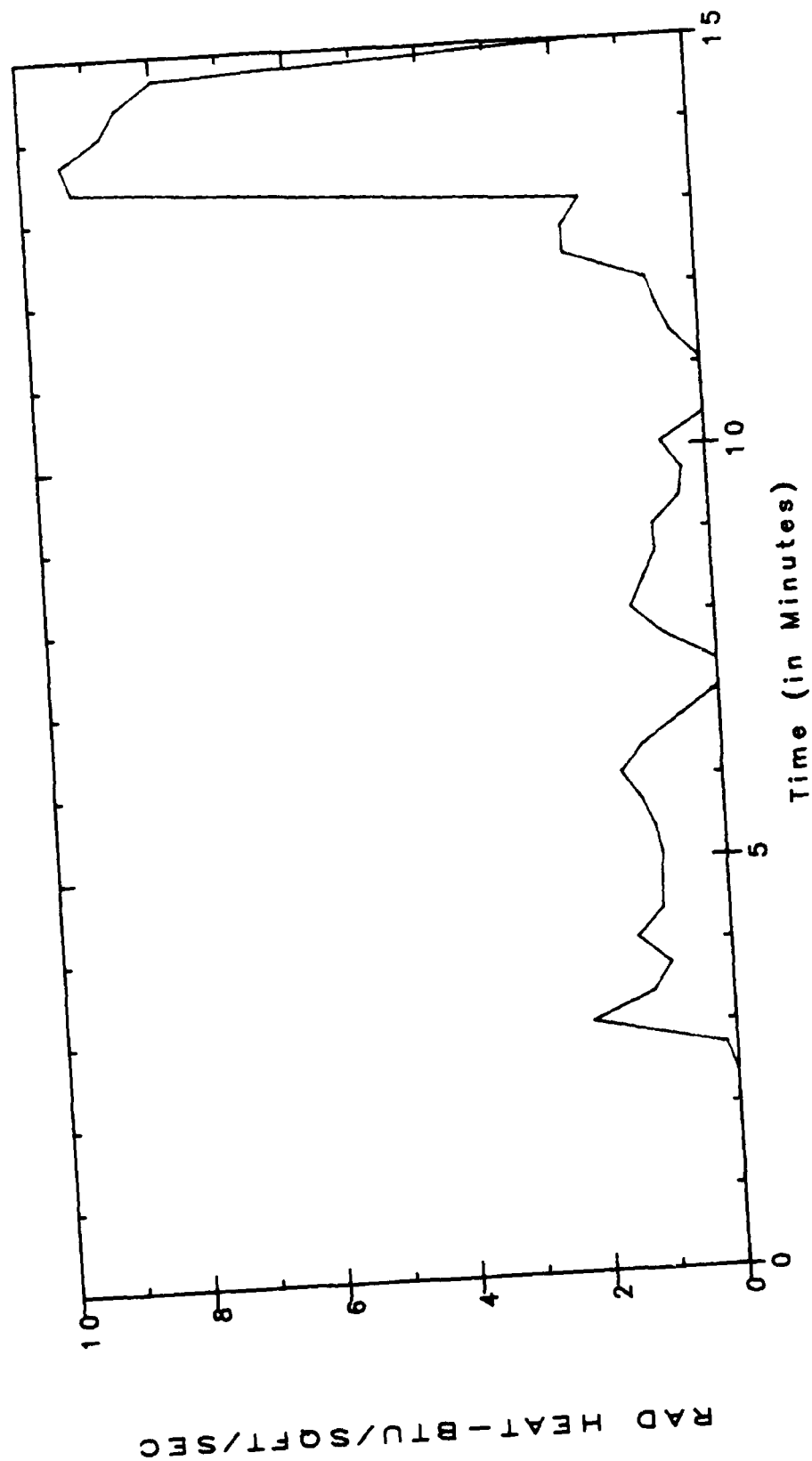
TIME/TEMPERATURE DATA

TANK TESTS



HEAT FLUX DATA

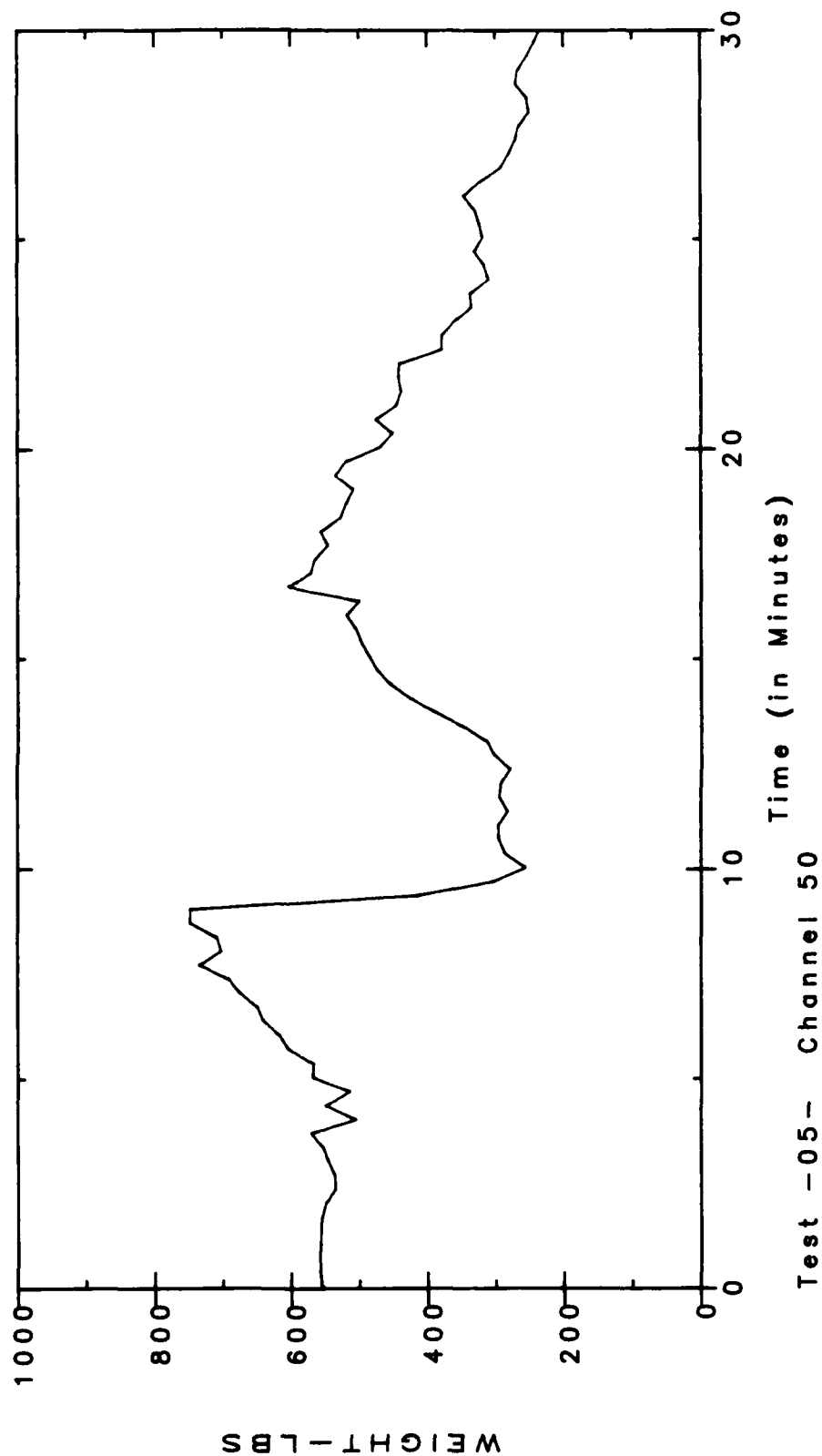
TANK TESTS



Test -05 - Channel 56

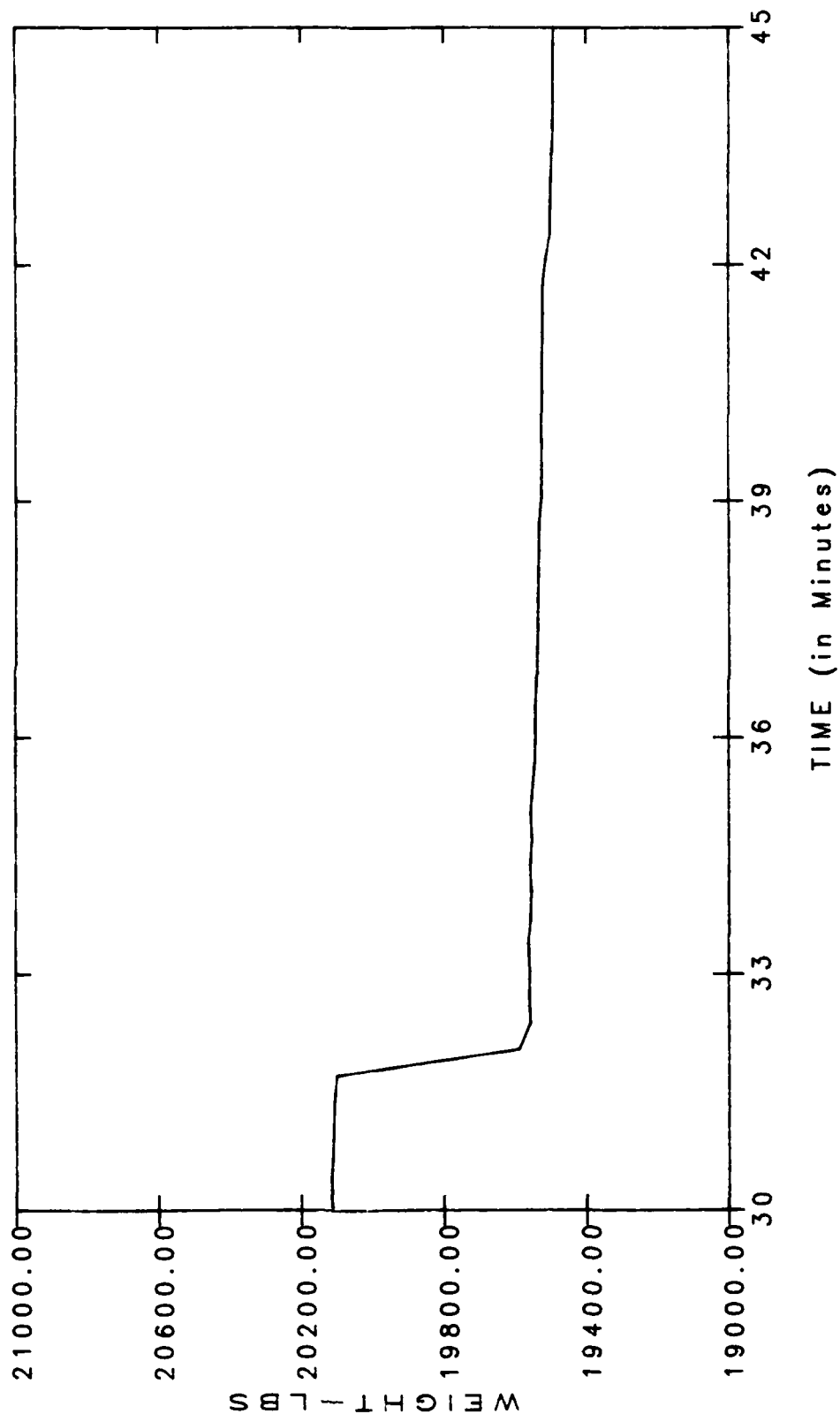
HEAT FLUX DATA
RADIANT HEAT

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TANK TESTS



43--05-049

WEIGHT LOSS DATA
CARDOX TANK

TEST # 6

TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 23 JUNE 1986

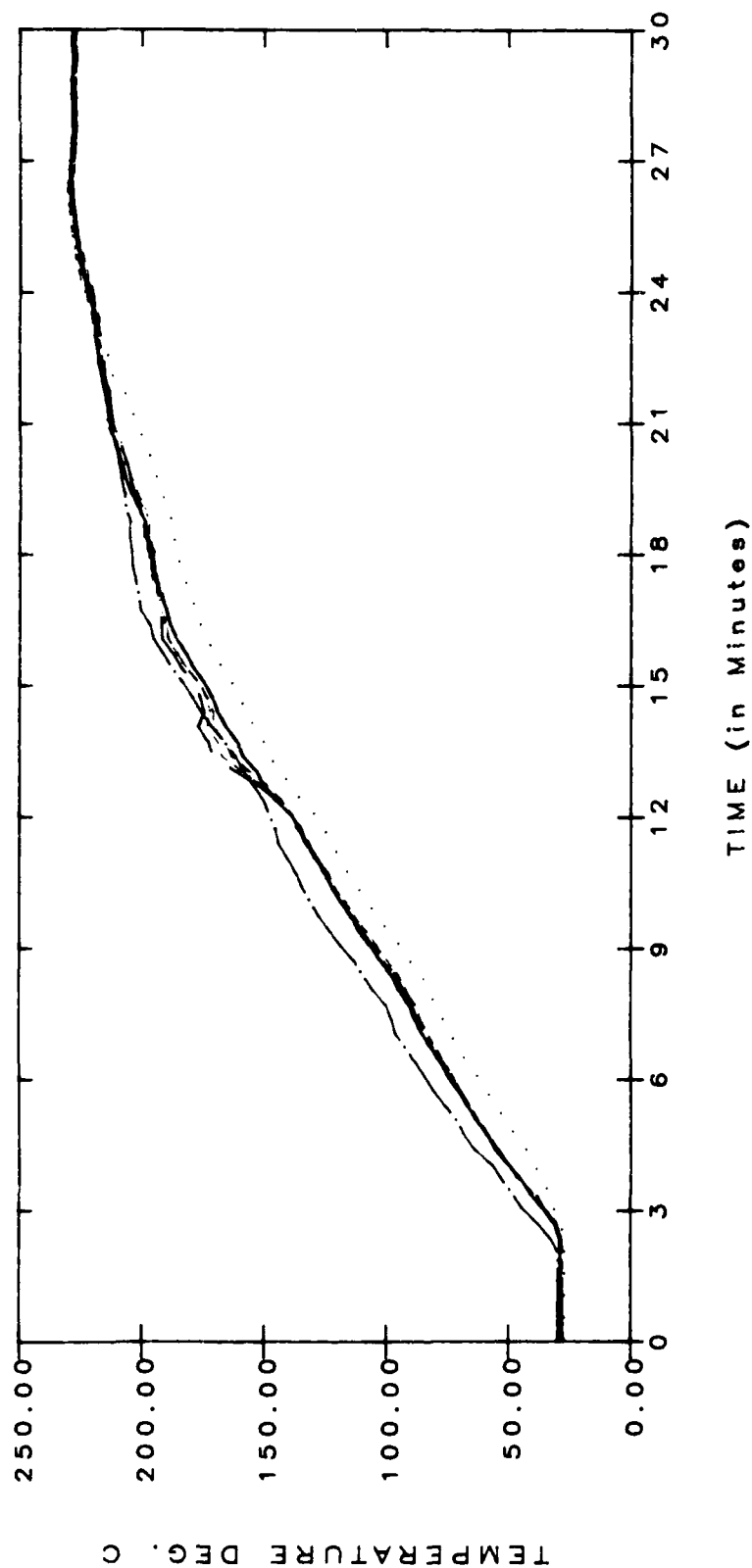
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:13:23 POLE ACROSS PIT MOVED. TANK DID NOT APPEAR TO RUPTURE
00:33:06 ONLY FLAMES AROUND VALVE

CAMERA LOCATION: 03 DECK

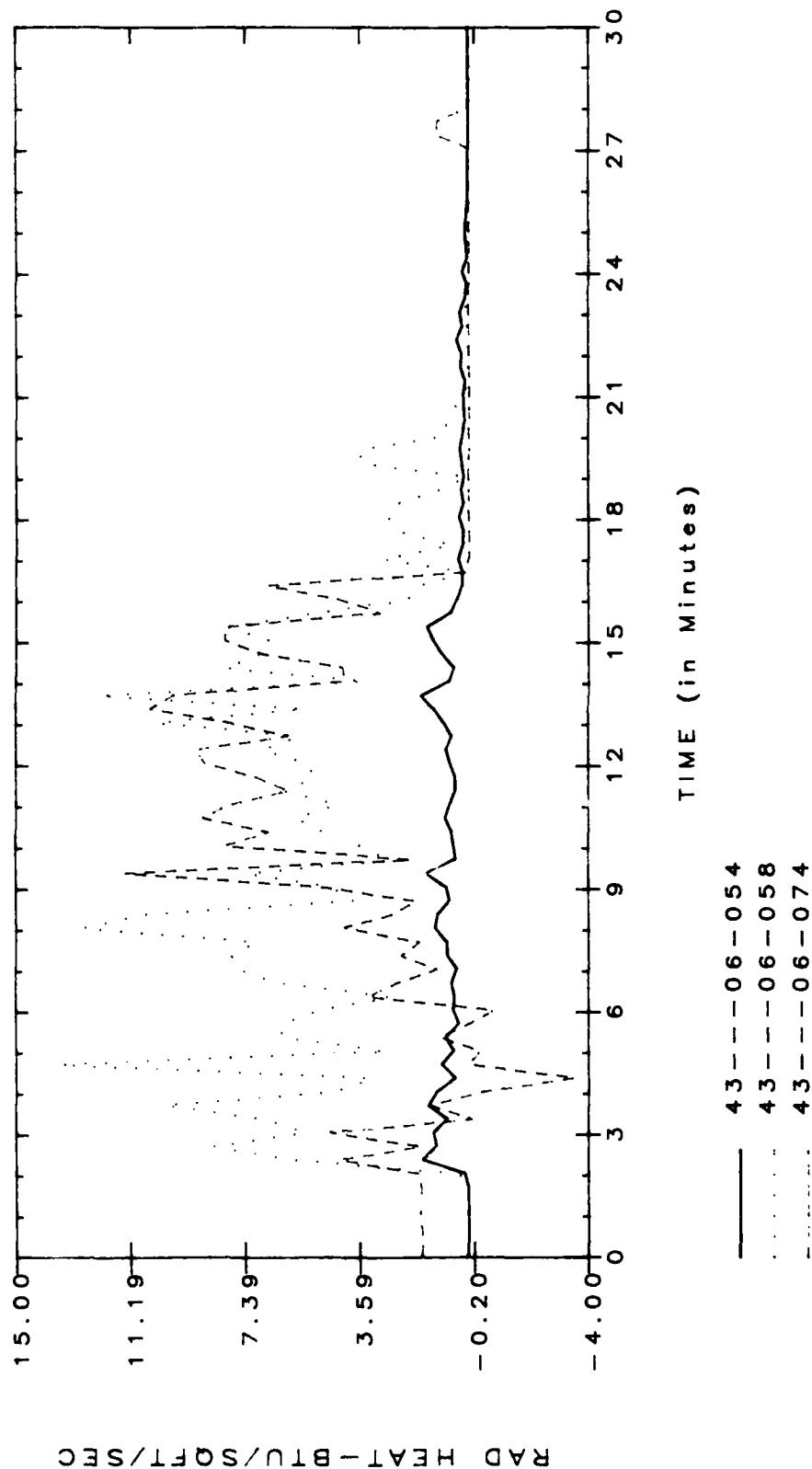
00:25:00 TANK OBSCURED BY FLAMES/SMOKE. TANK DID NOT APPEAR TO
FAIL
FLAMING AROUND VALVE - TOP OF TANK
TANK APPEAR INTACT

TANK TESTS



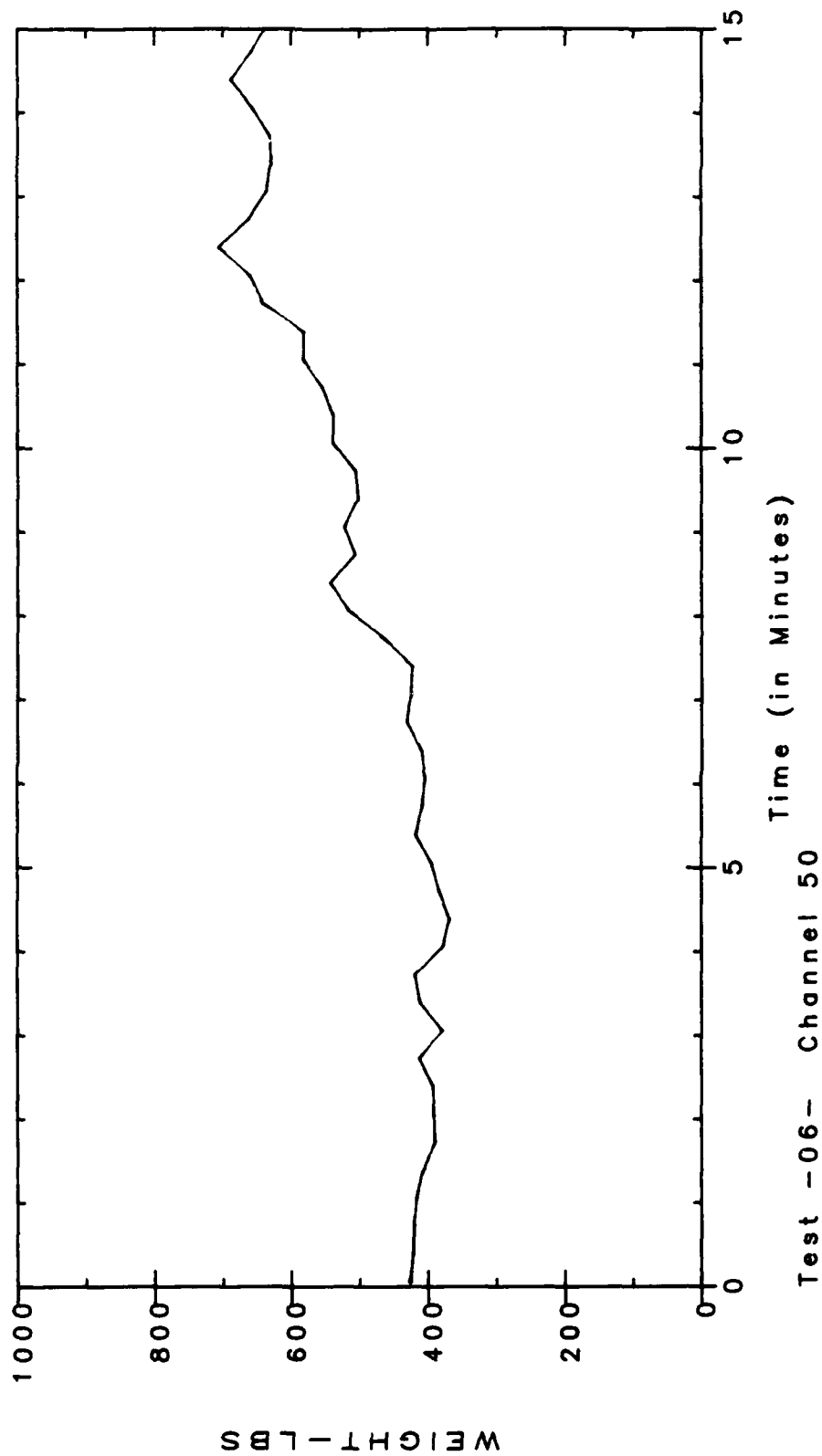
TIME/TEMPERATURE DATA

TANK TESTS



HEAT FLUX DATA RADIANT HEAT

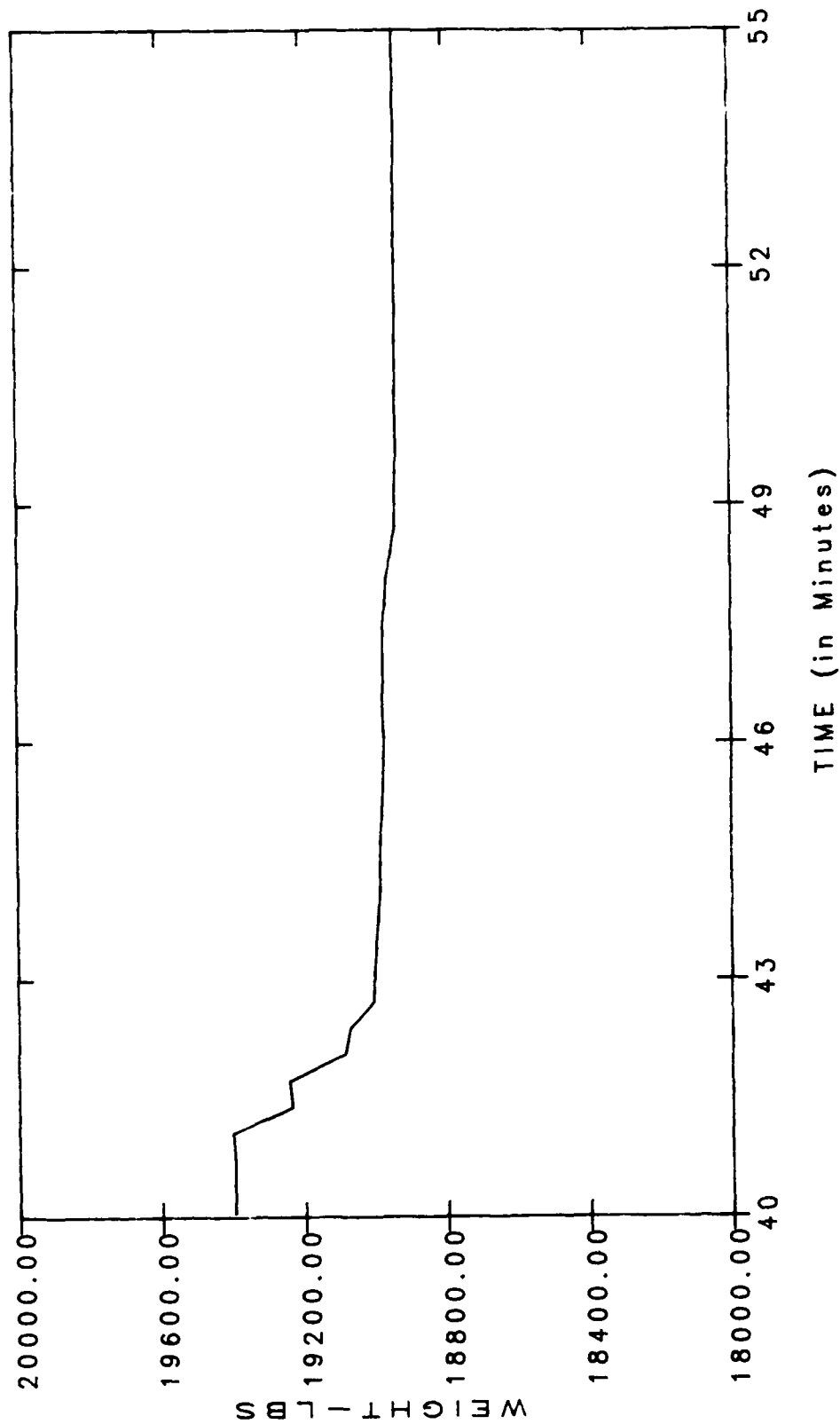
TANK TESTS



WEIGHT LOSS DATA
TEST TANK

Test -06-- Channel 50

TANK TESTS



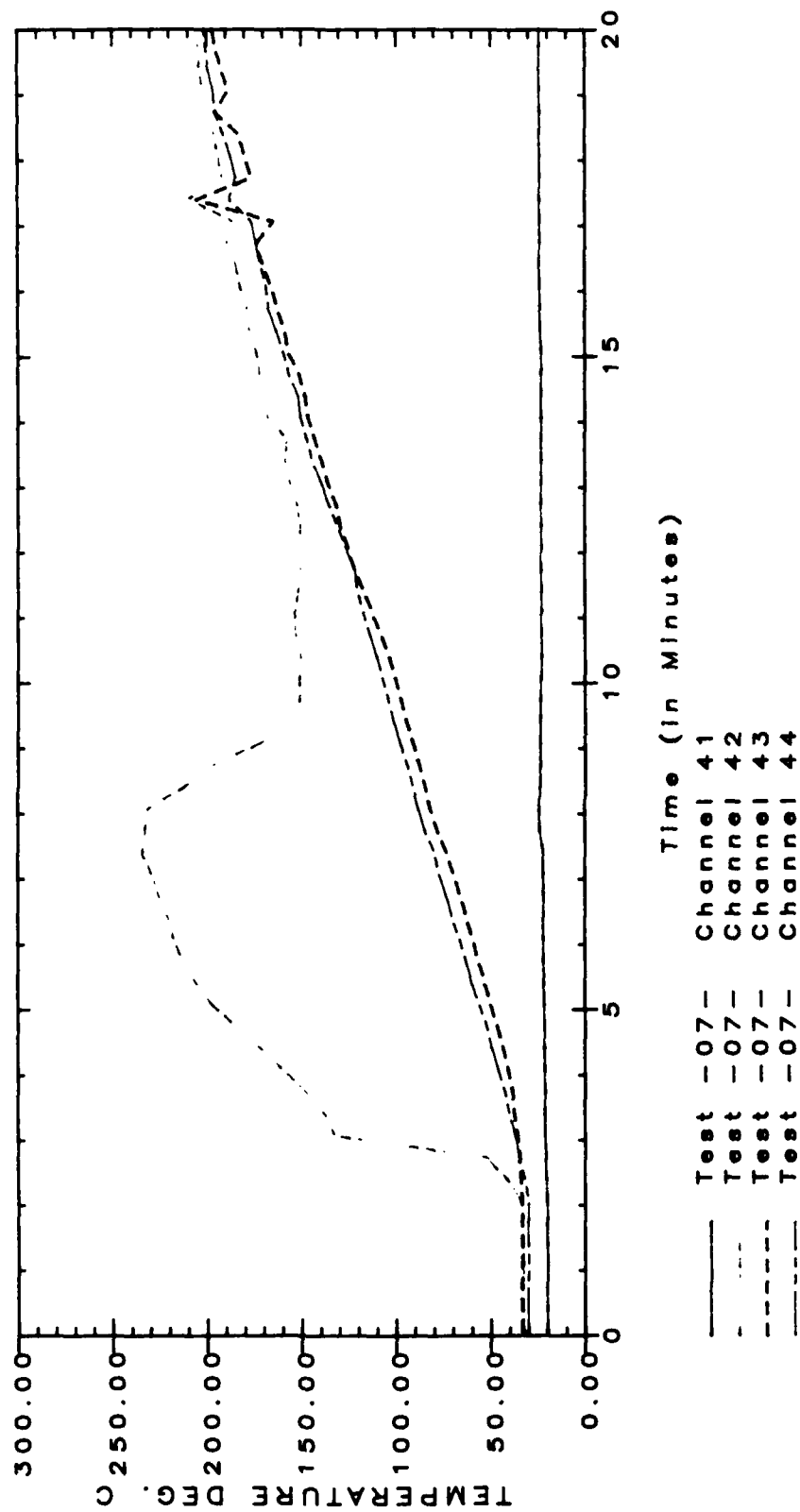
43-- --06-049

WEIGHT LOSS DATA
CARDOX TANK

TEST # 7

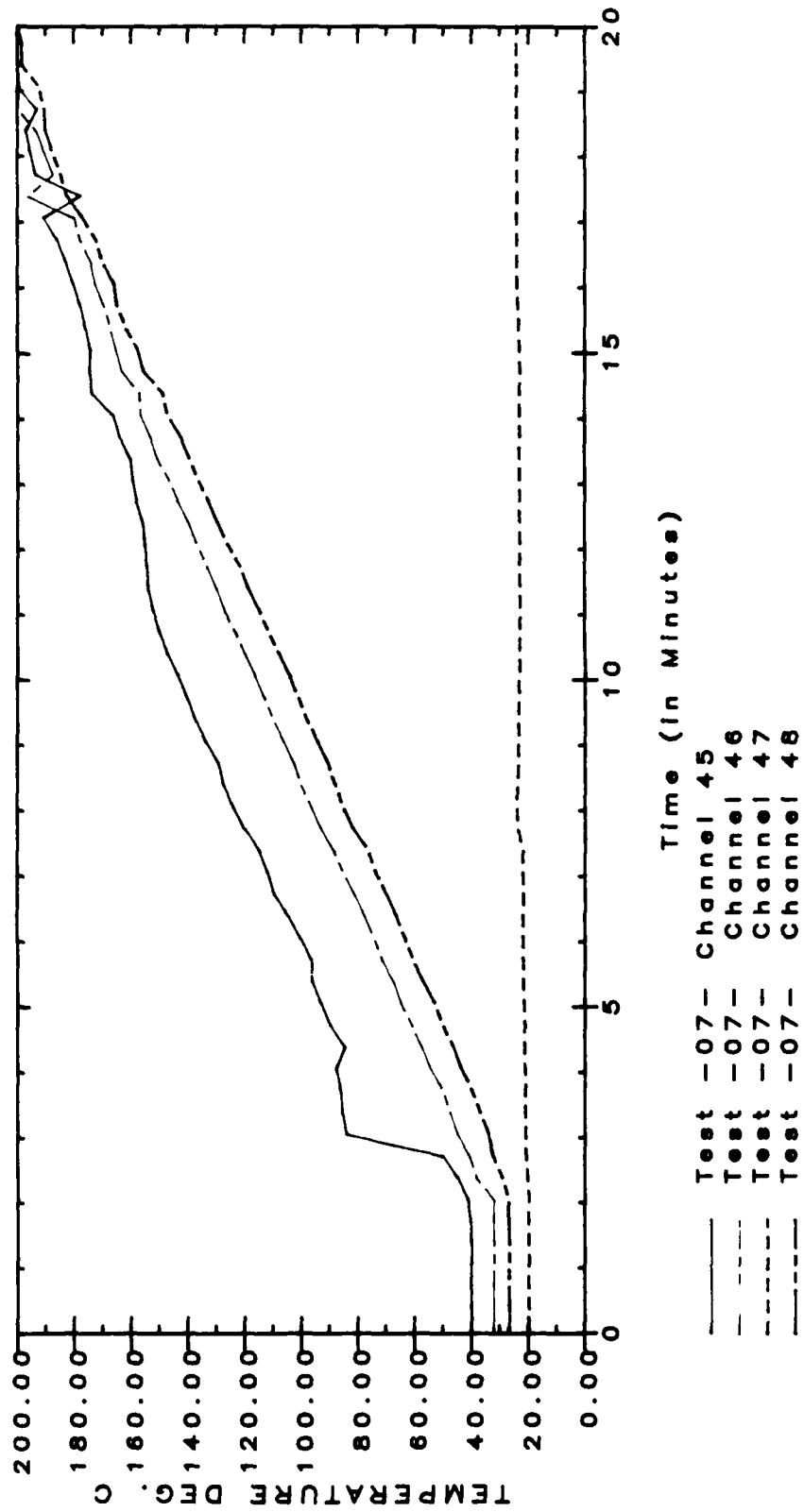
TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETHYL ALCOHOL
PAN FIRE SIZE: 100 SQ. FT.
NO VIDEO:

TANK TESTS



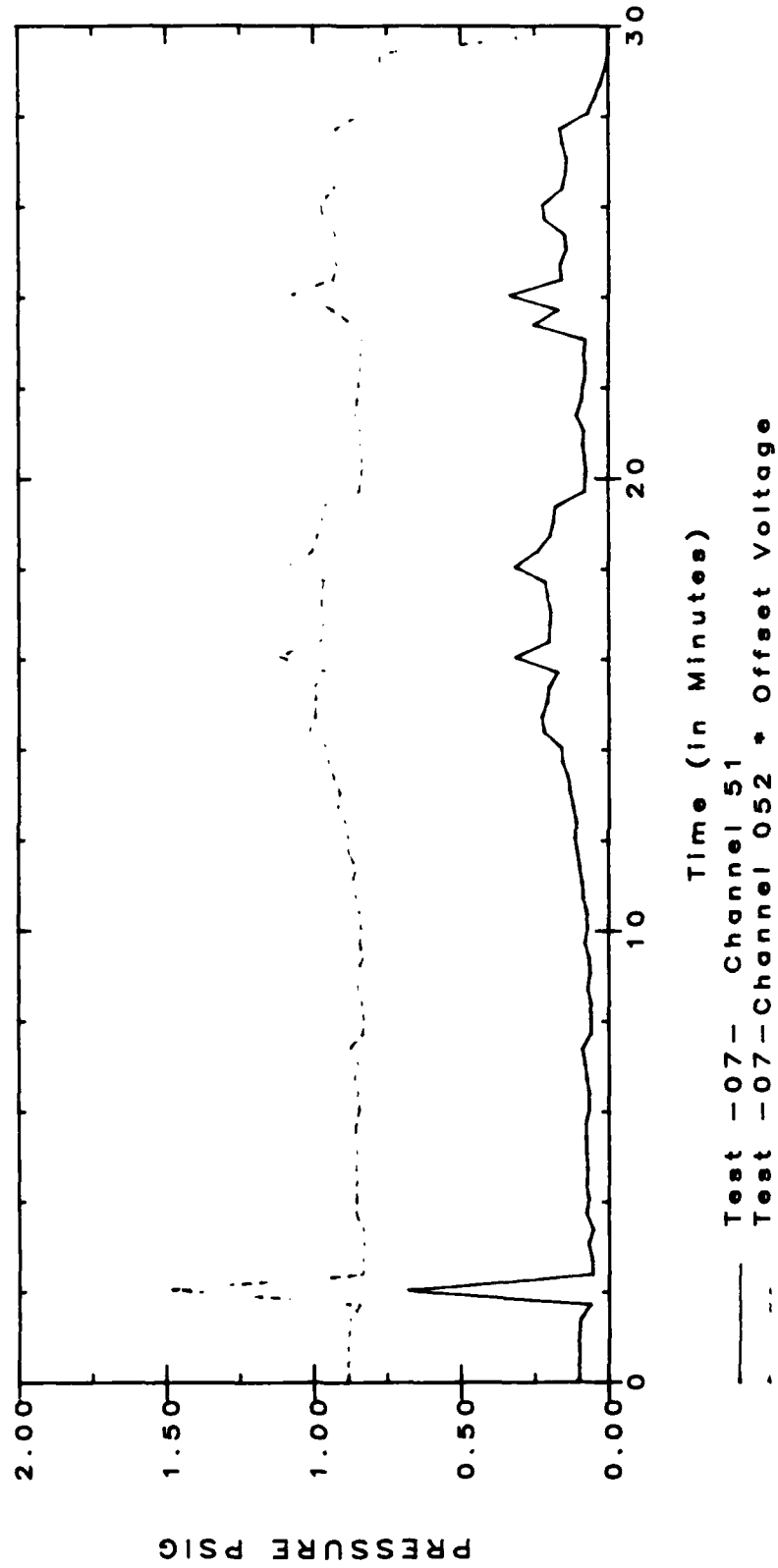
TIME/TEMPERATURE DATA

TANK TESTS



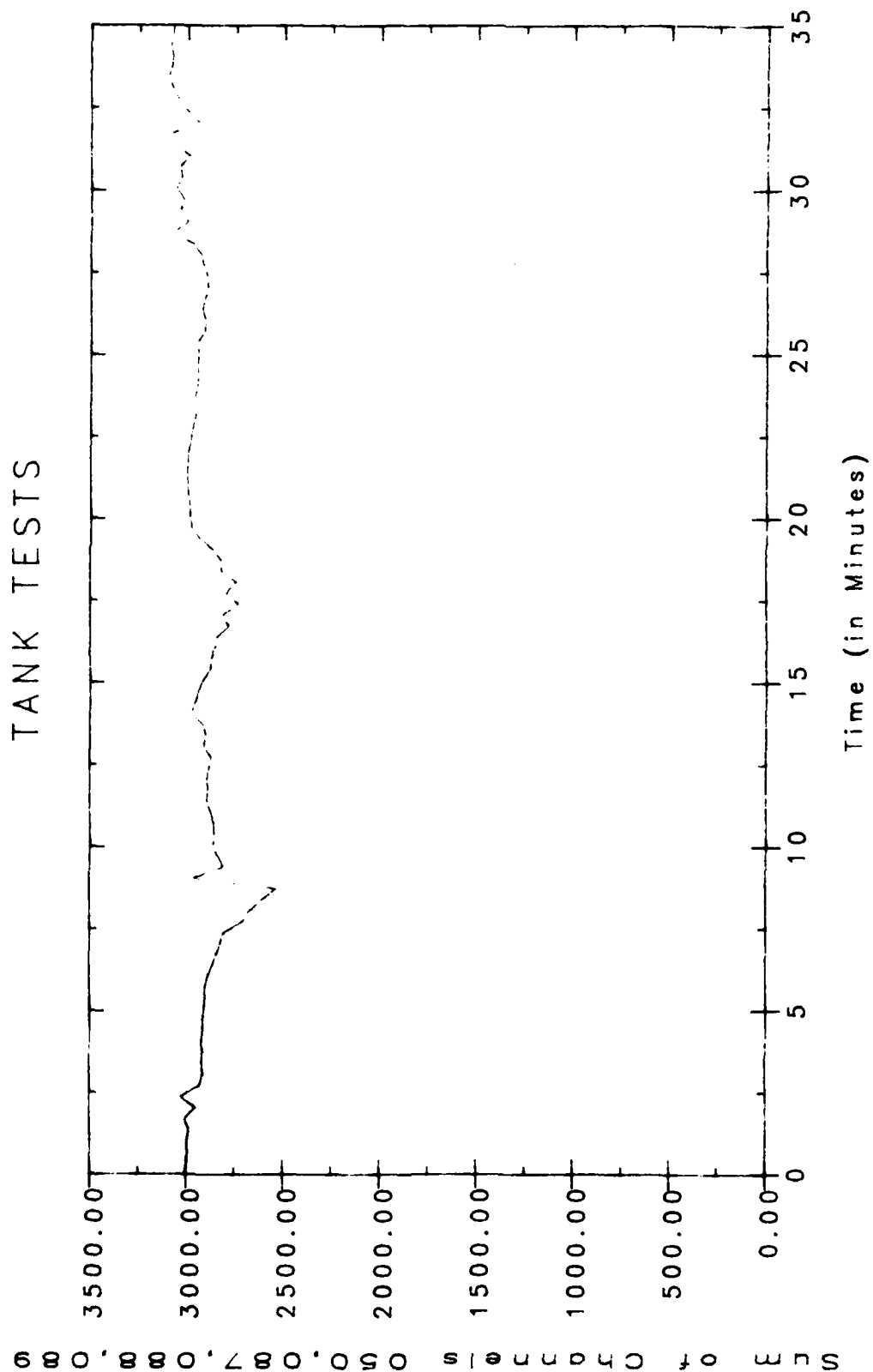
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TEST # 8

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 28 JUNE 1986

CAMERA LOCATION: MAINDECK

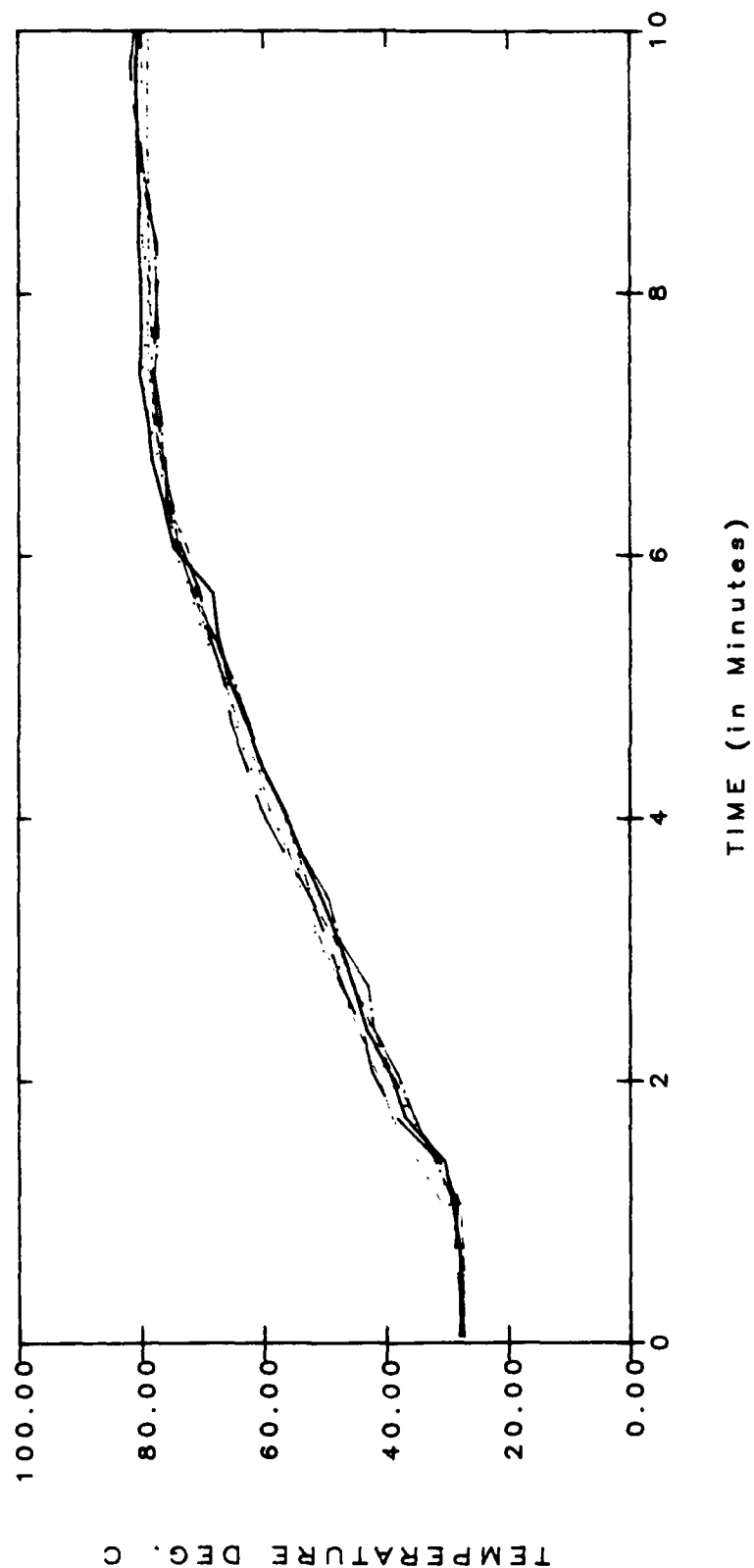
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

SMOKE/FLAMES COMPLETELY OBSCURING TANK. CAMERA
APPEARS TO BE TOO CLOSE - SMOKE BLOWING INTO LENS
00:12:00 TANK VISIBLE - APPEARS INTACT. APPEAR TO BE VAPORS
FROM TANK - ON FIRE
00:13:50 VAPORS FROM VALVE FLAMING, PIT FIRE DYING DOWN
00:26:00 SMALL VAPOR FIRE FROM VALVE - PIT FIRE OUT
00:27:07 TANK EXTINGUISHED WITH CO2
00:27:09 FIRE OUT

CAMERA LOCATION: 03 DECK

00:02:16 RUPTURE (FROM VOICE - B. MCLAIN)
00:06:32 TANK VENTS FROM VALVE
00:06:56 PLUME FIRE (FROM VOICE - B. MCLAIN)
00:13:50 FLAME - TOP OF TANK - PIT FIRE DYING DOWN
00:26:24 PIT FIRE OUT - FLAME FROM TOP OF TANK
00:27:07 CO2 APPLICATION
00:27:09 FIRE OUT

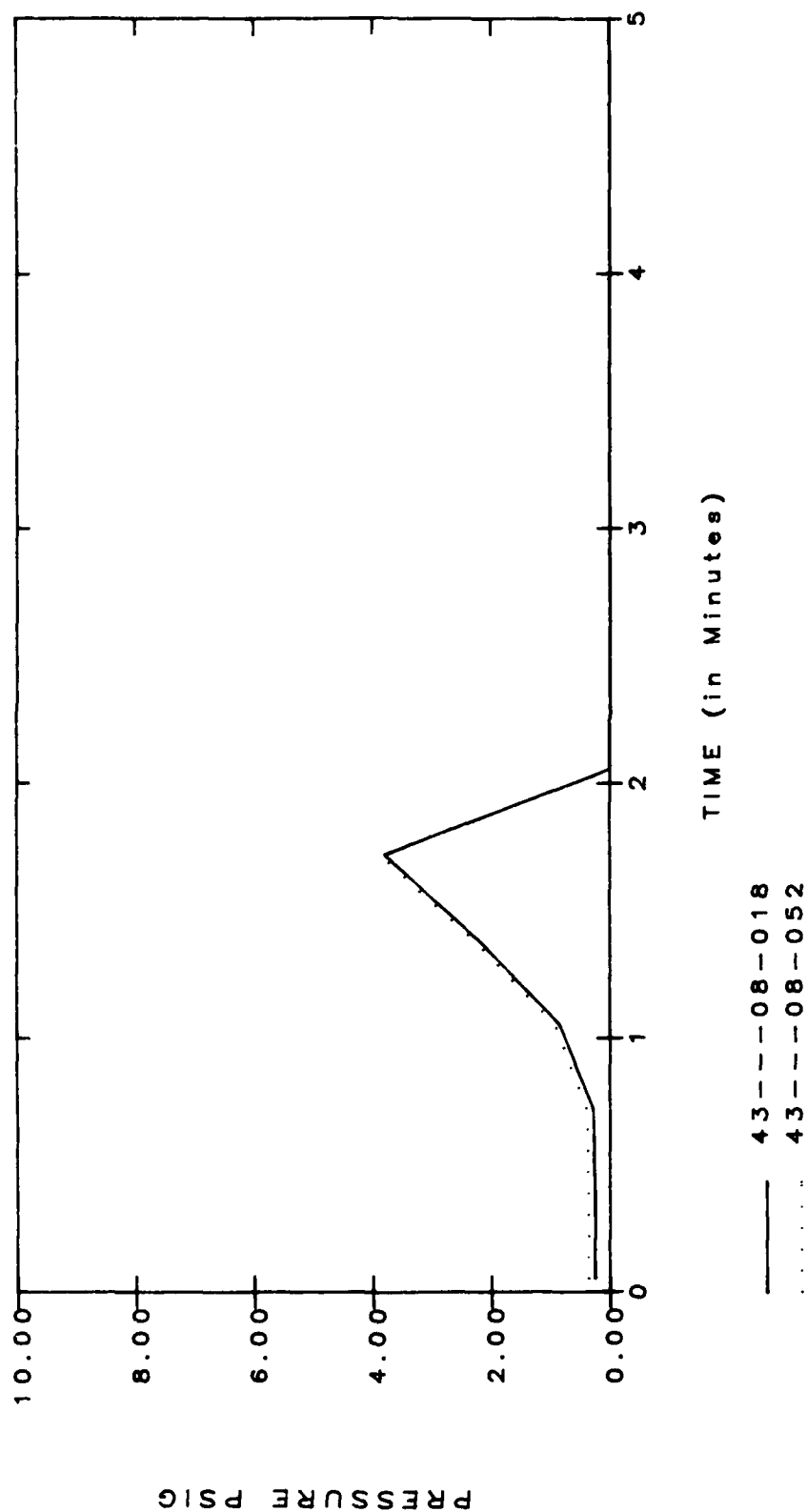
TANK TESTS



43--08-045
 43--08-046
 43--08-047
 43--08-048
 43--08-041
 43--08-044

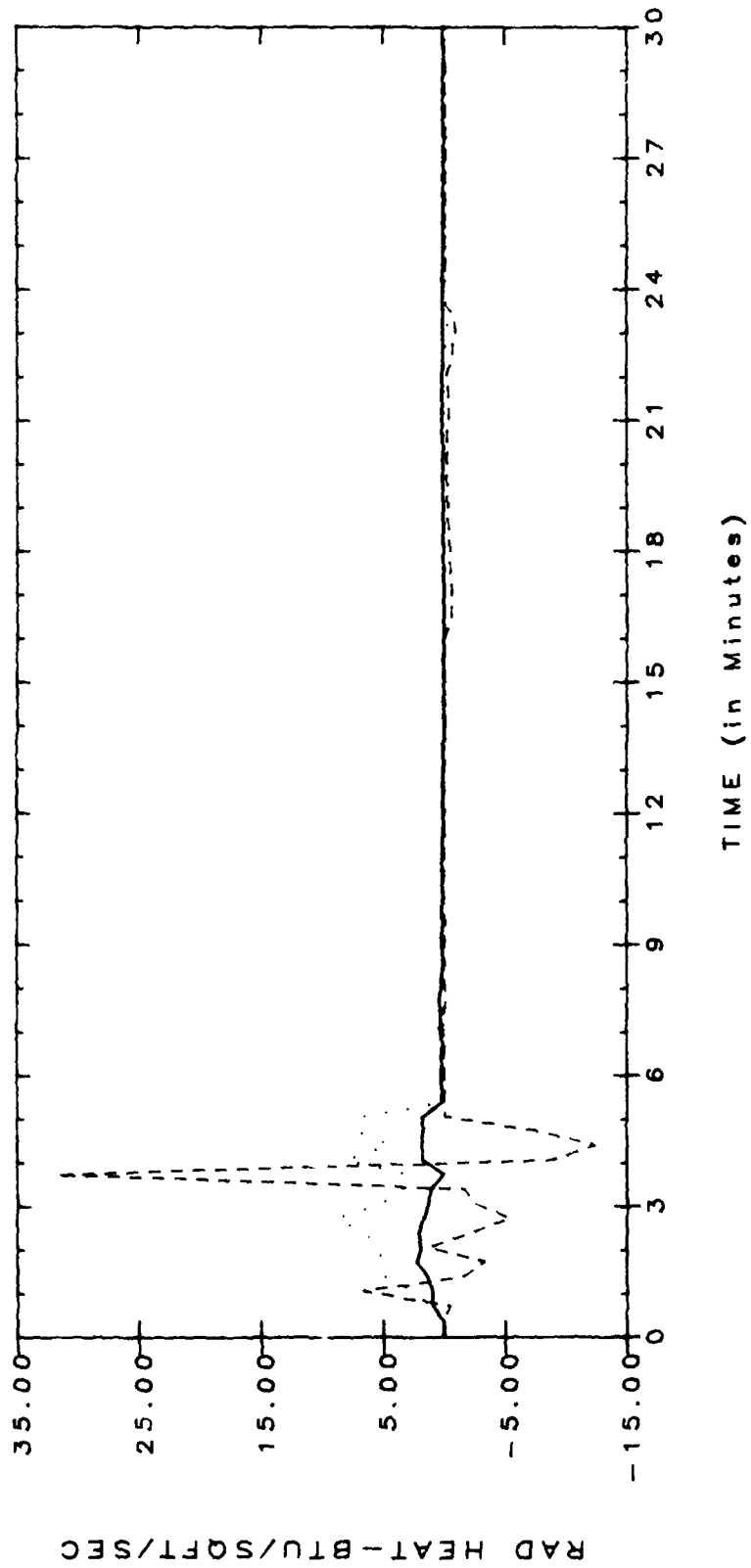
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

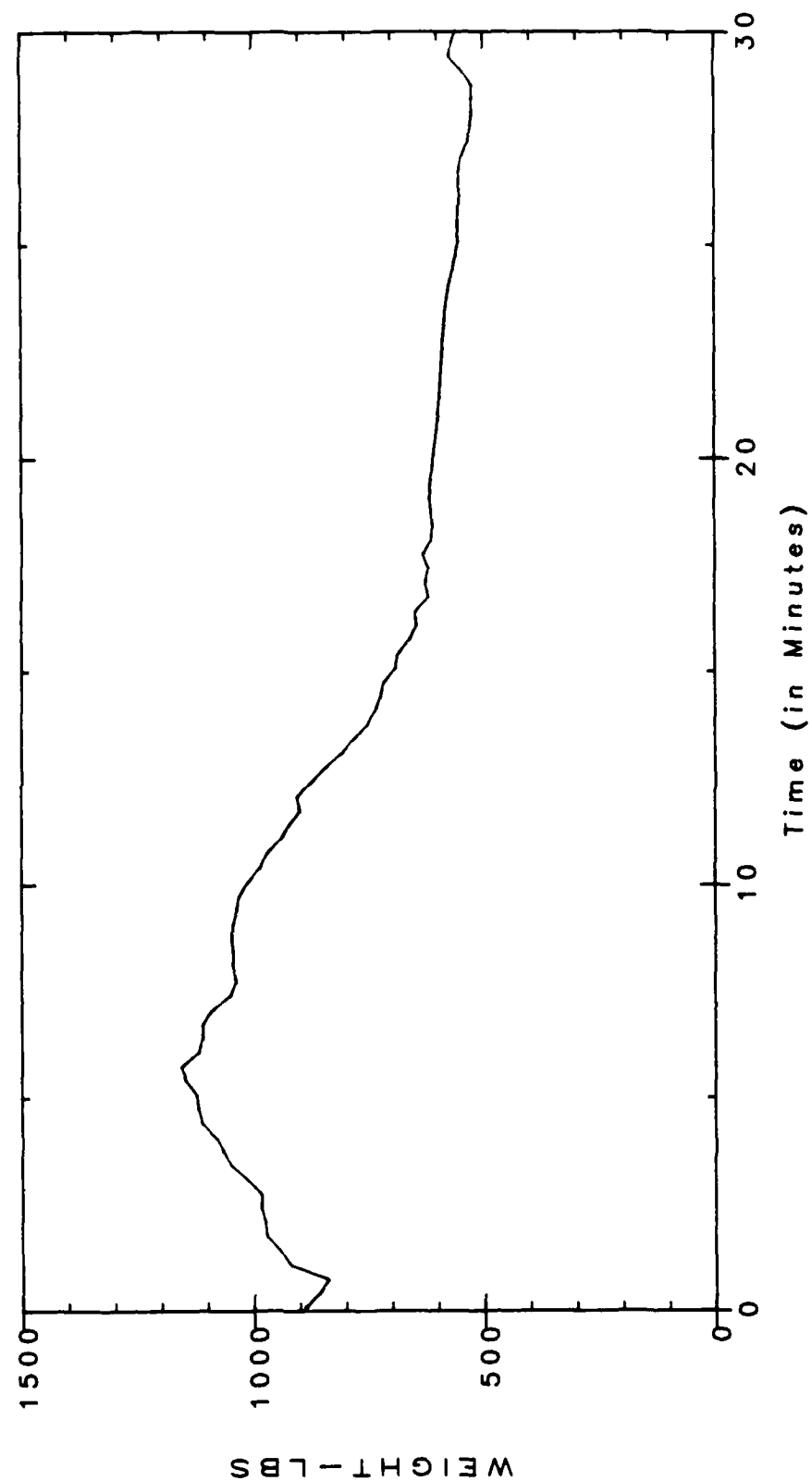
TANK TESTS



HEAT FLUX DATA
RADIANT HEAT

43-08-053
43-08-057
43-08-073

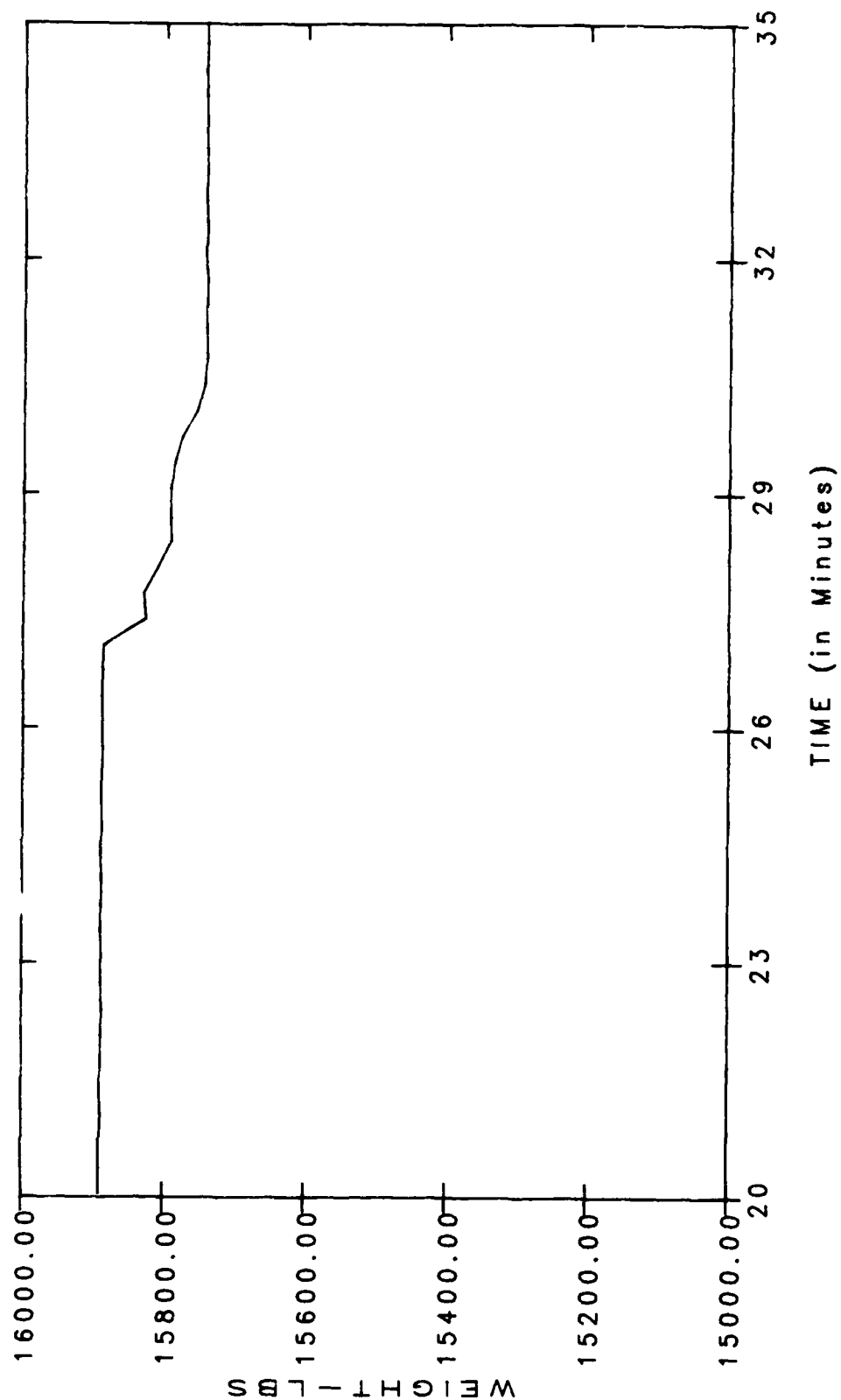
TANK TESTS



Test -08- Channel 50

WEIGHT LOSS DATA
TEST TANK

TANK TESTS



43-08-049

WEIGHT LOSS DATA
CARDOX TANK

TEST # 9

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 11 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:07:50 VENTED (TOP)
FIRE PLUME
00:12:10 FIRE EXTINGUISHED

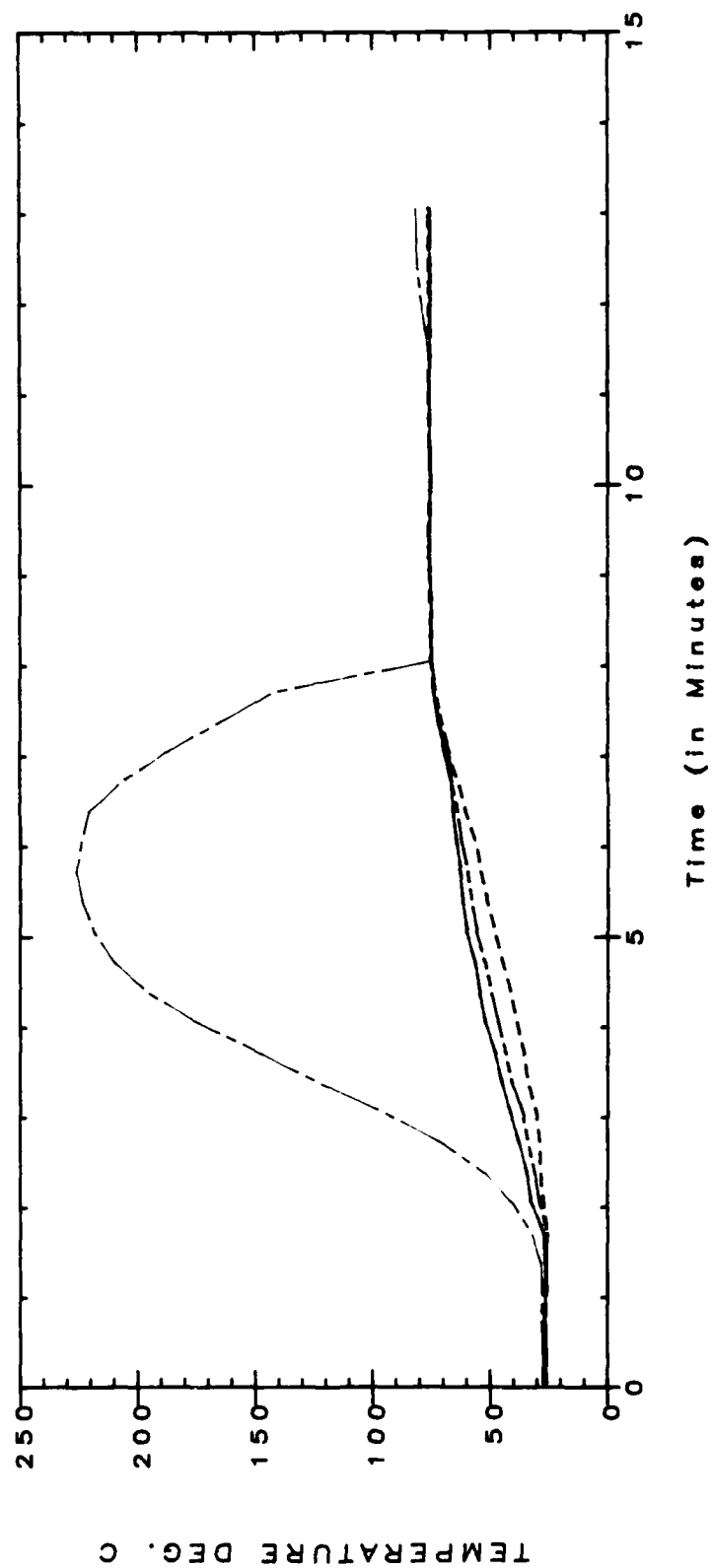
CAMERA LOCATION: 03 DECK

00:07:30 CAMERA OFF

CAMERA LOCATION: 04 DECK

00:07:30 CAMERA OFF

TANK TESTS

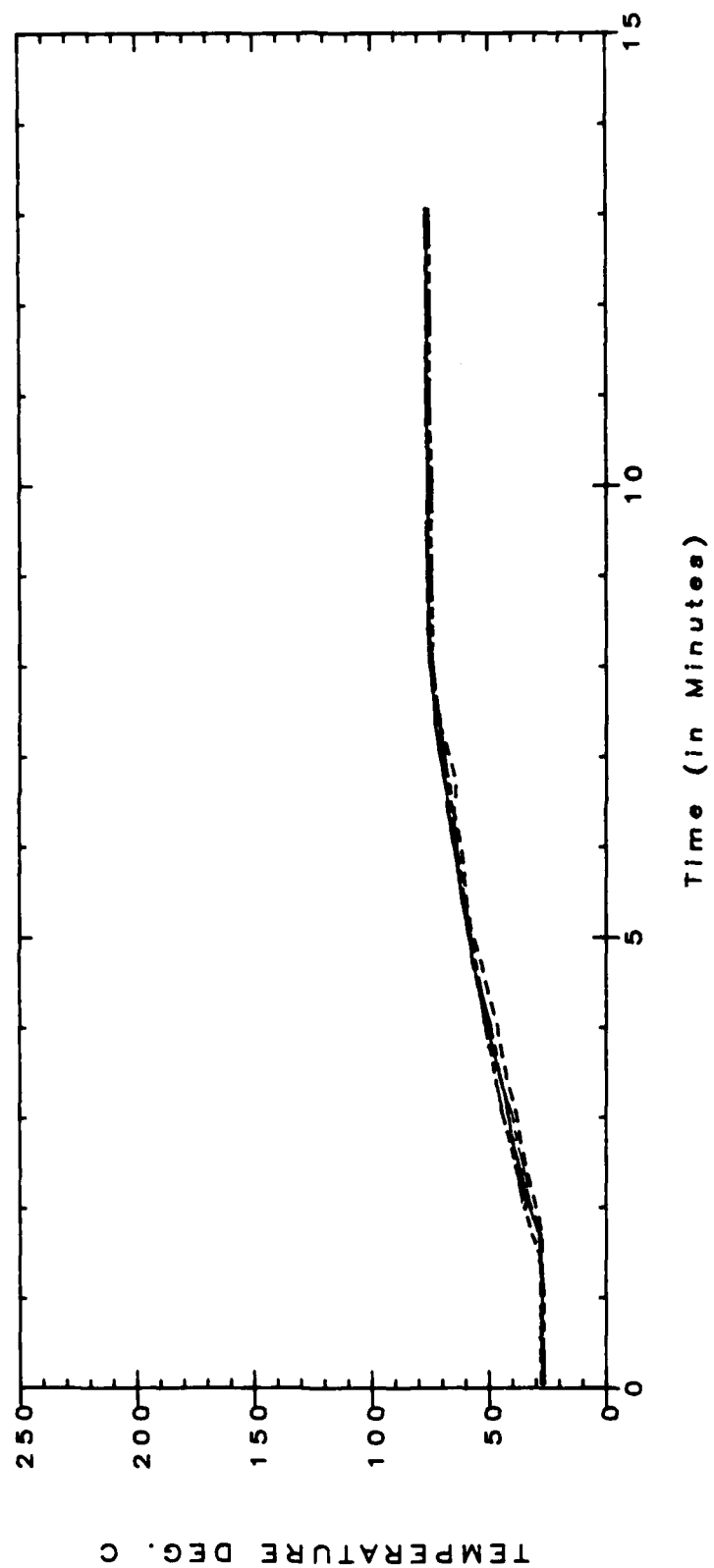


Time (in Minutes)

Test - 00 - Channel 41
 Test - 09 - Channel 42
 Test - 09 - Channel 43
 Test - 09 - Channel 44

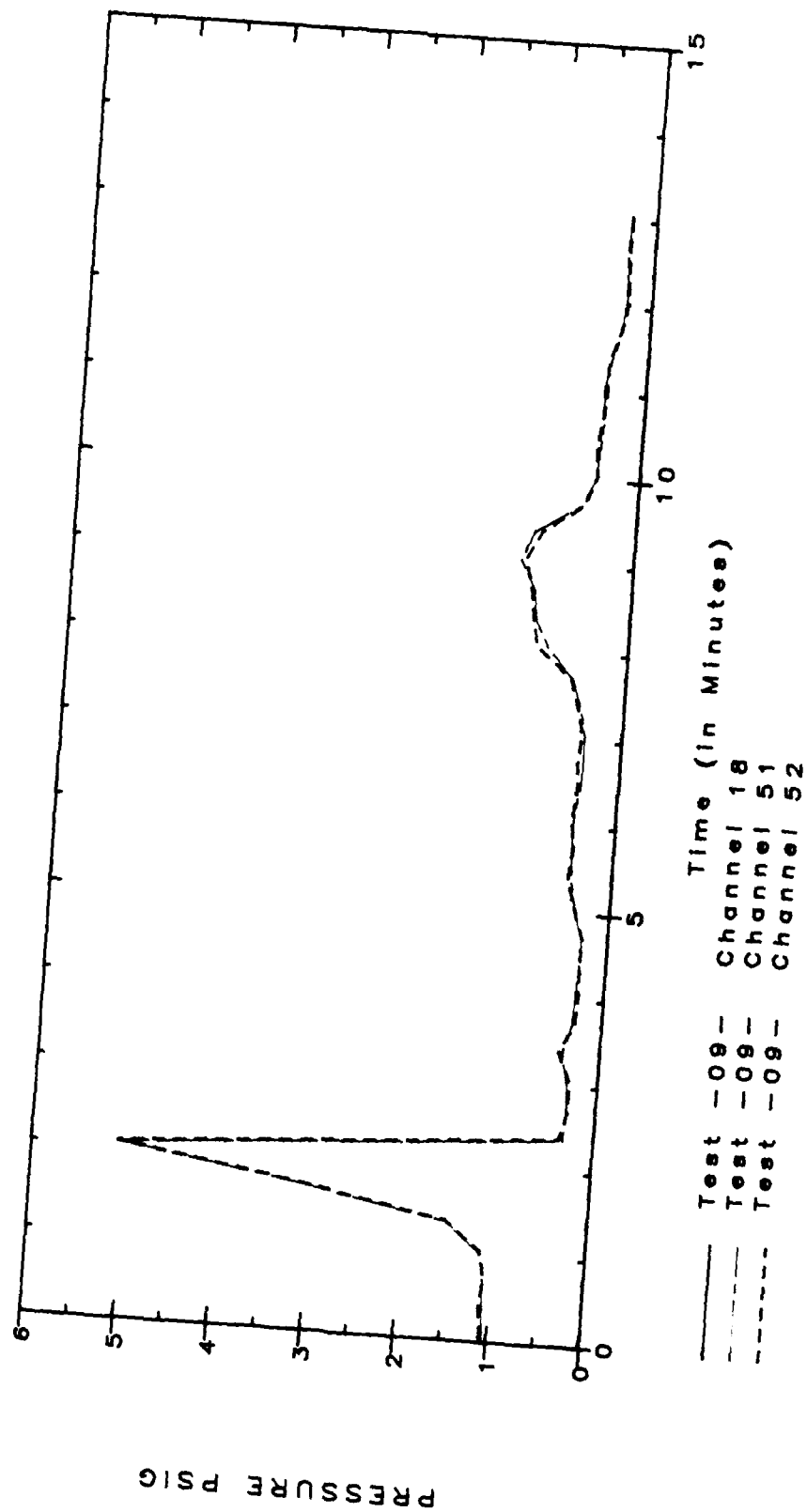
TIME/TEMPERATURE DATA

TANK TESTS



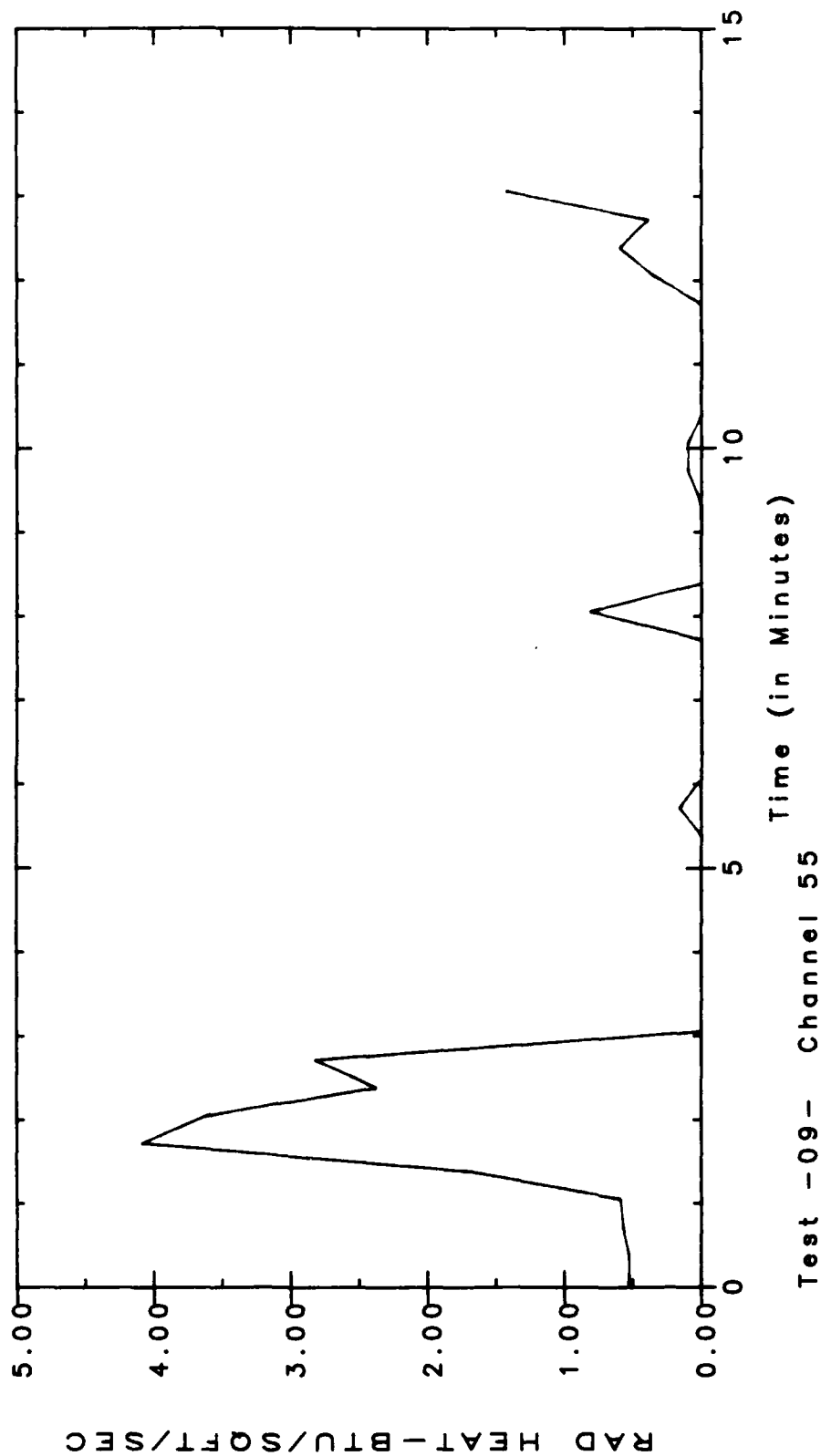
TIME/TEMPERATURE DATA

TANK TESTS



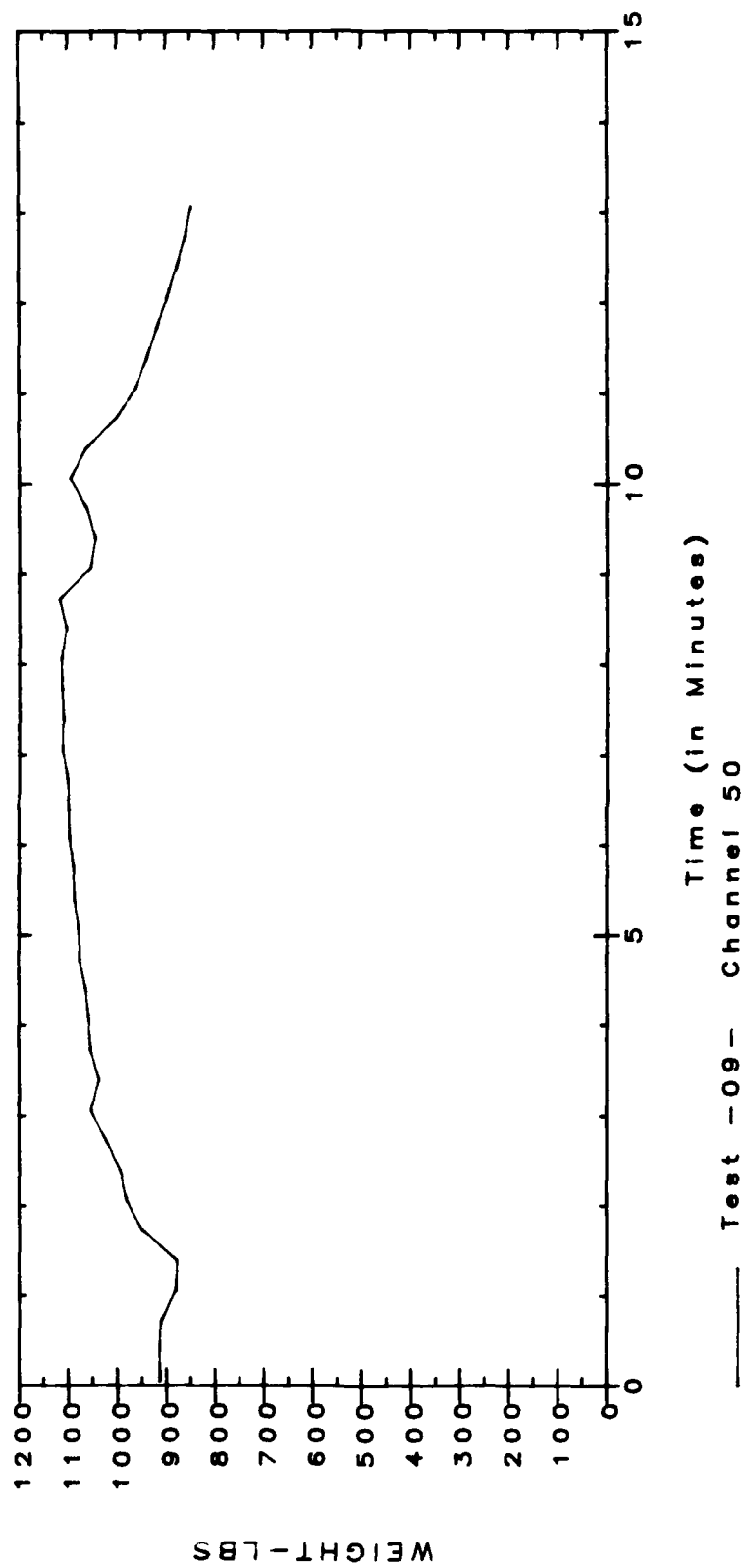
IN-TANK PRESSURE DATA

TANK TESTS



HEAT FLUX DATA
RADIANT HEAT

TANK TESTS



WEIGHT LOSS DATA TEST TANK

TEST # 10

TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 10 JUNE 1986

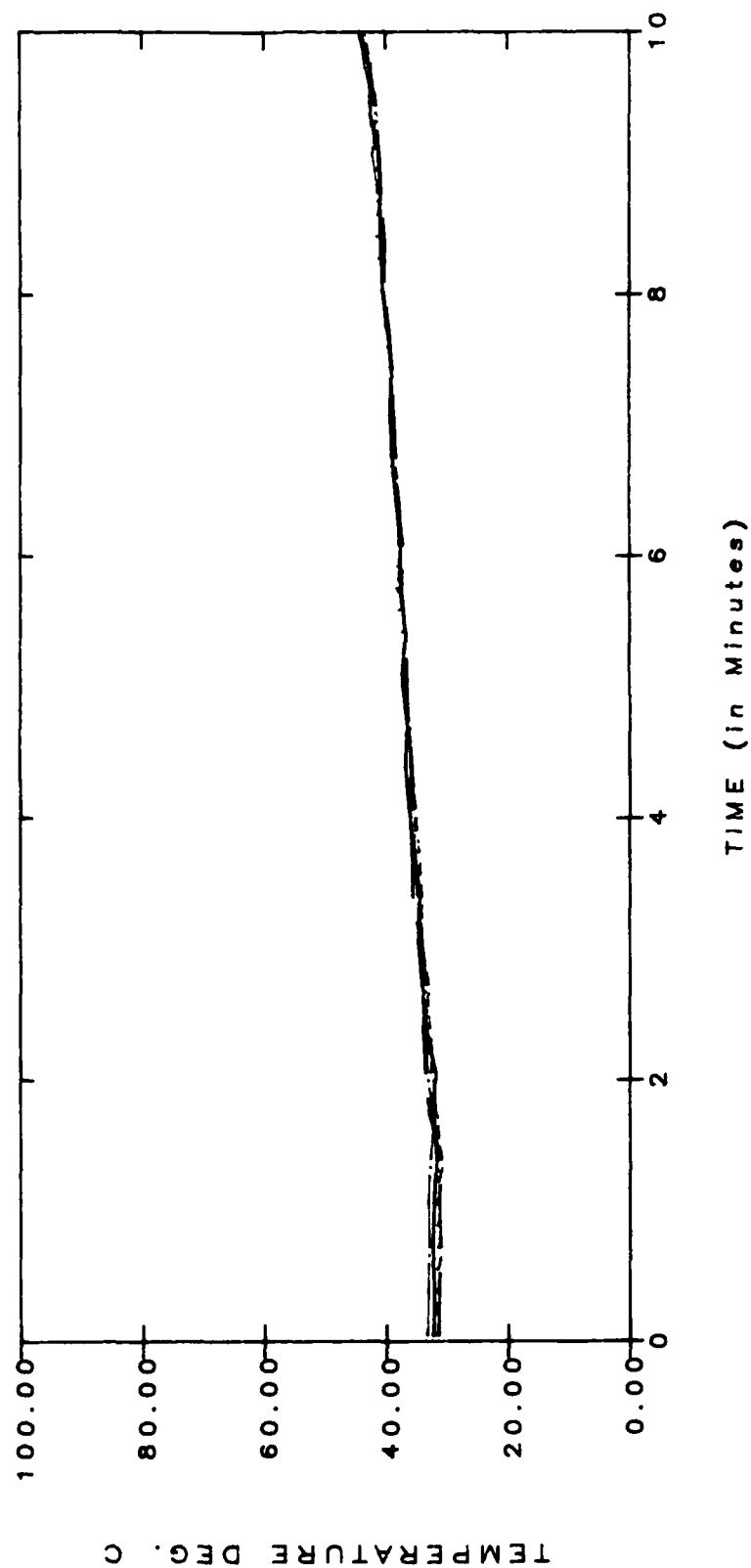
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:23:10 FIRE IMPINGING - VALVE LEAK AT BOTTOM
00:29:45 TANK TIPS TO ONE SIDE

CAMERA LOCATION: 03 DECK

00:23:11 TANK BOTTOM VALVE LEAK
00:29:46 TANK TIPS
00:46:03 FIRE ALMOST OUT

TANK TESTS



43-10-041
 43-10-044
 43-10-045
 43-10-046
 43-10-047
 43-10-048

TIME/TEMPERATURE DATA

GH-1-13553-10 050,087,088

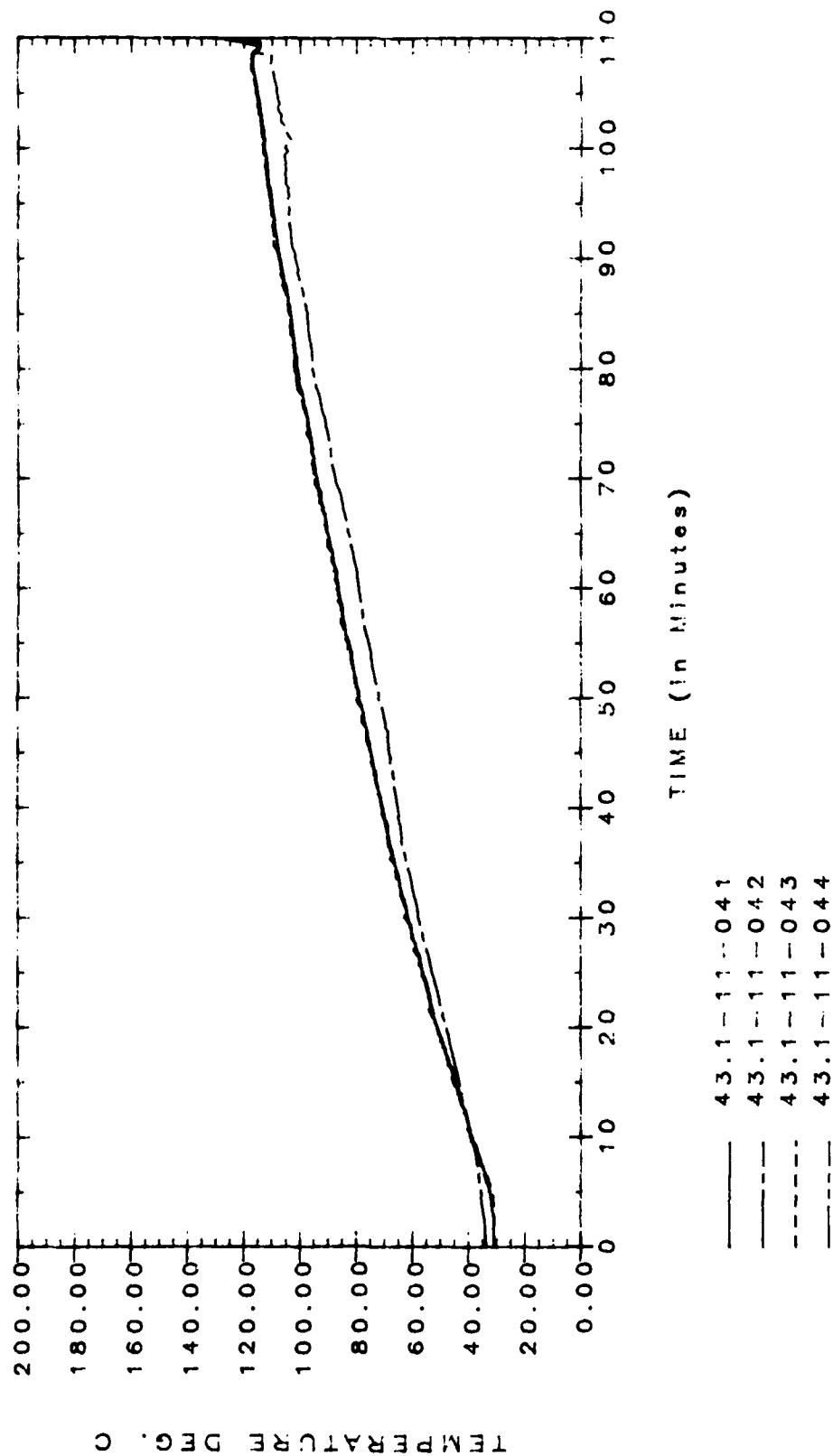


**WEIGHT LOSS DATA
TEST TANK**

TEST # 11

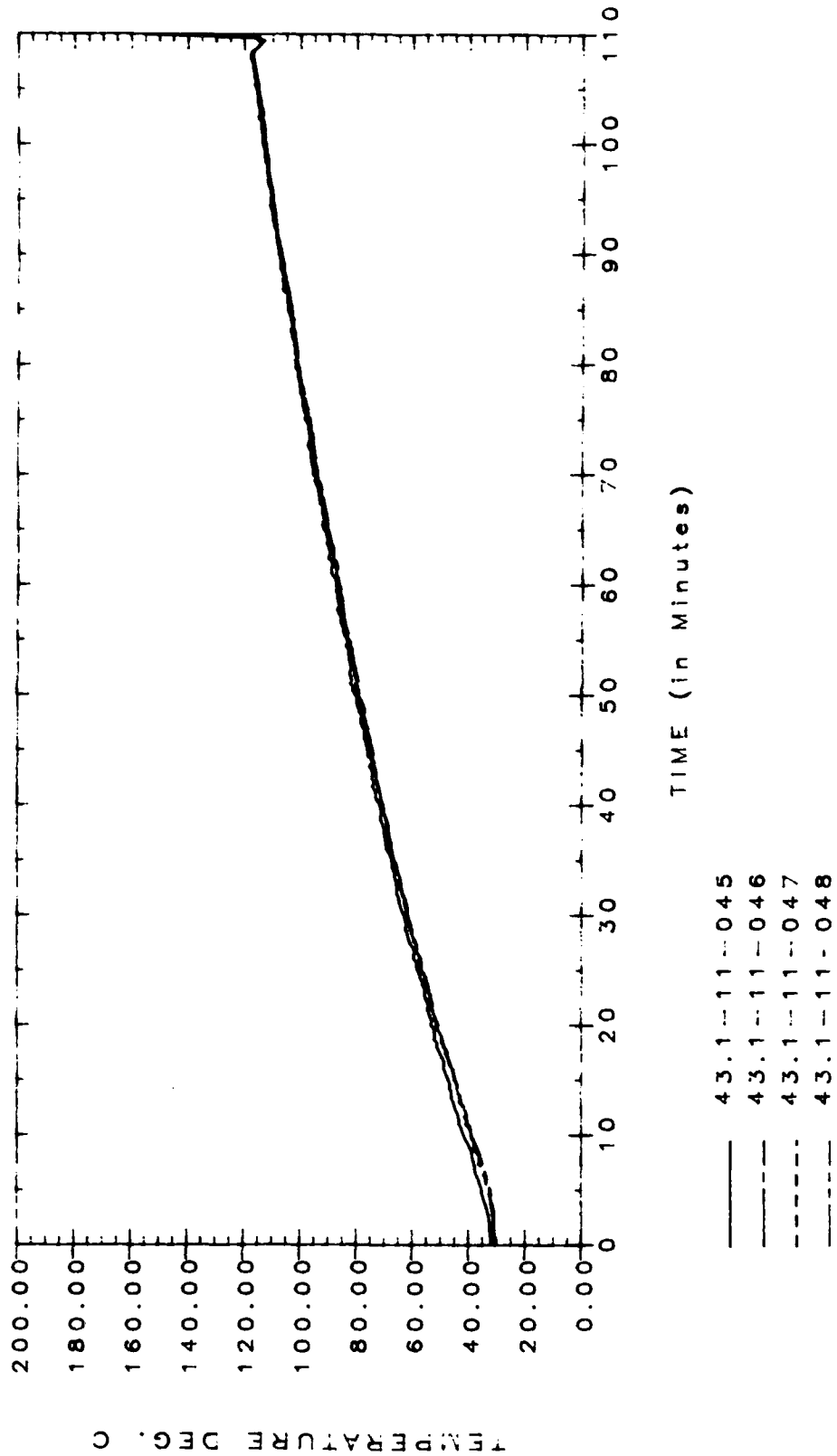
TYPE OF TANK: STEEL TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
NO VIDEO:

TANK TESTS



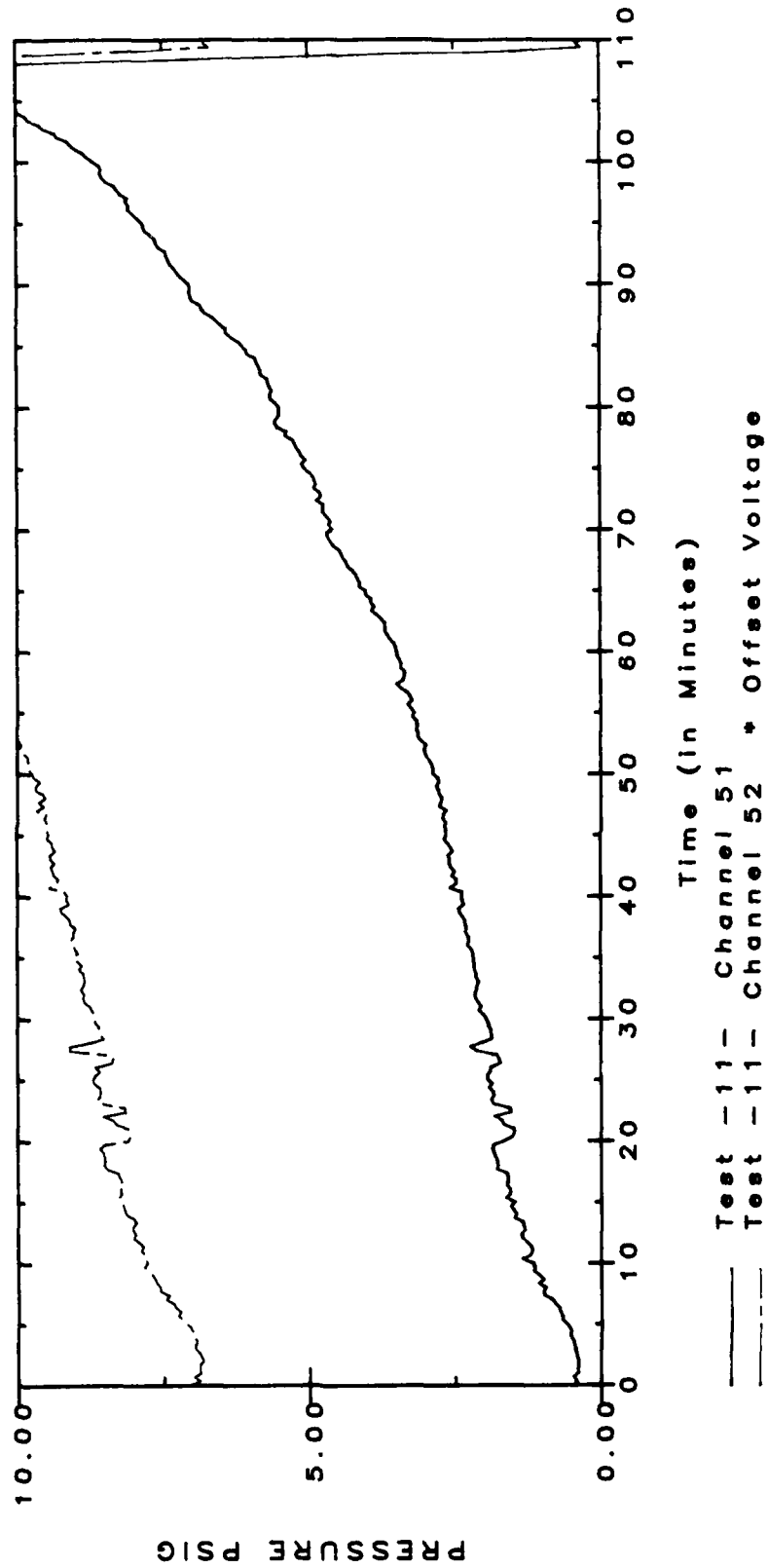
TIME/TEMPERATURE DATA

TANK TESTS



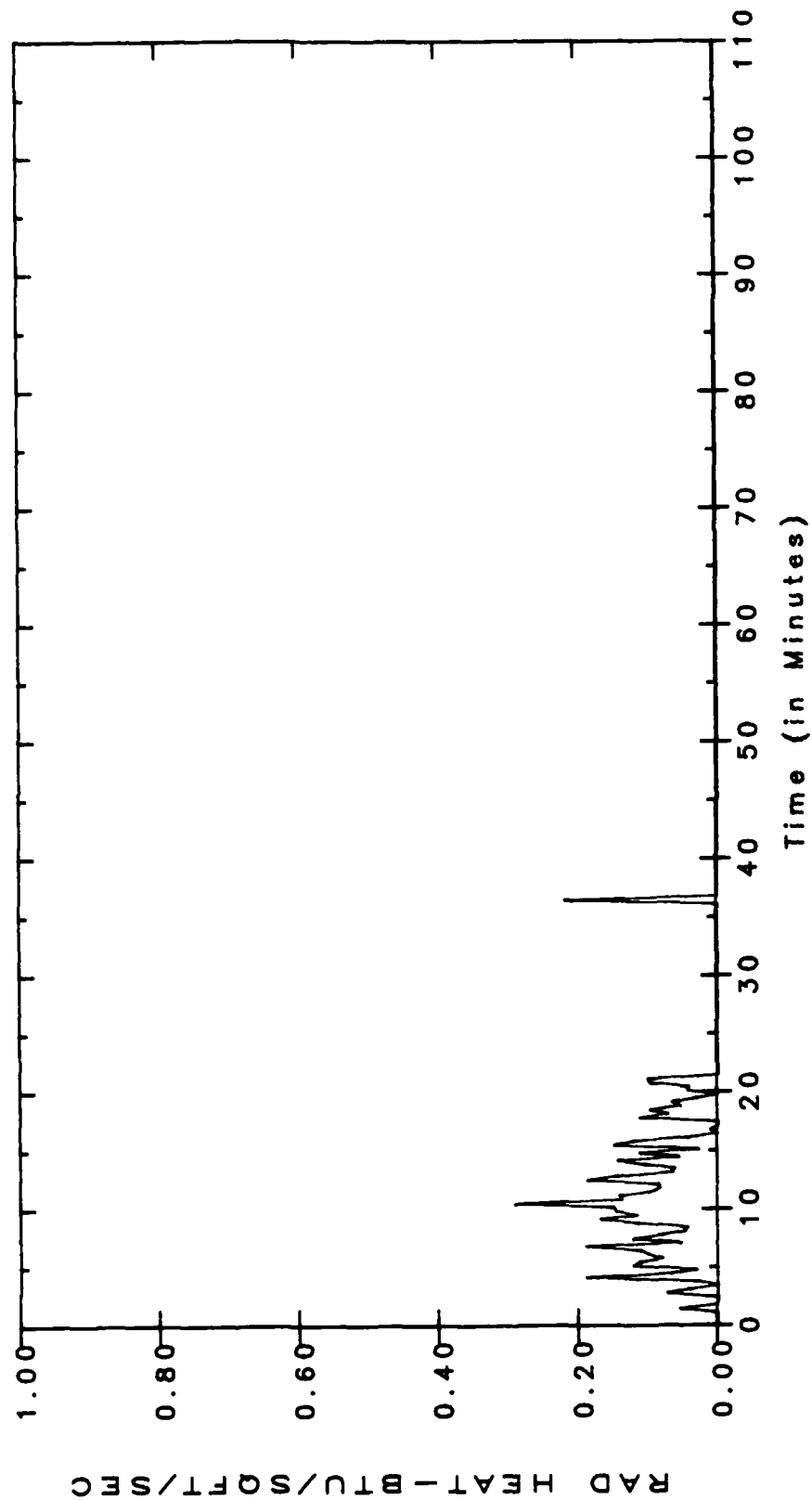
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

TANK TESTS

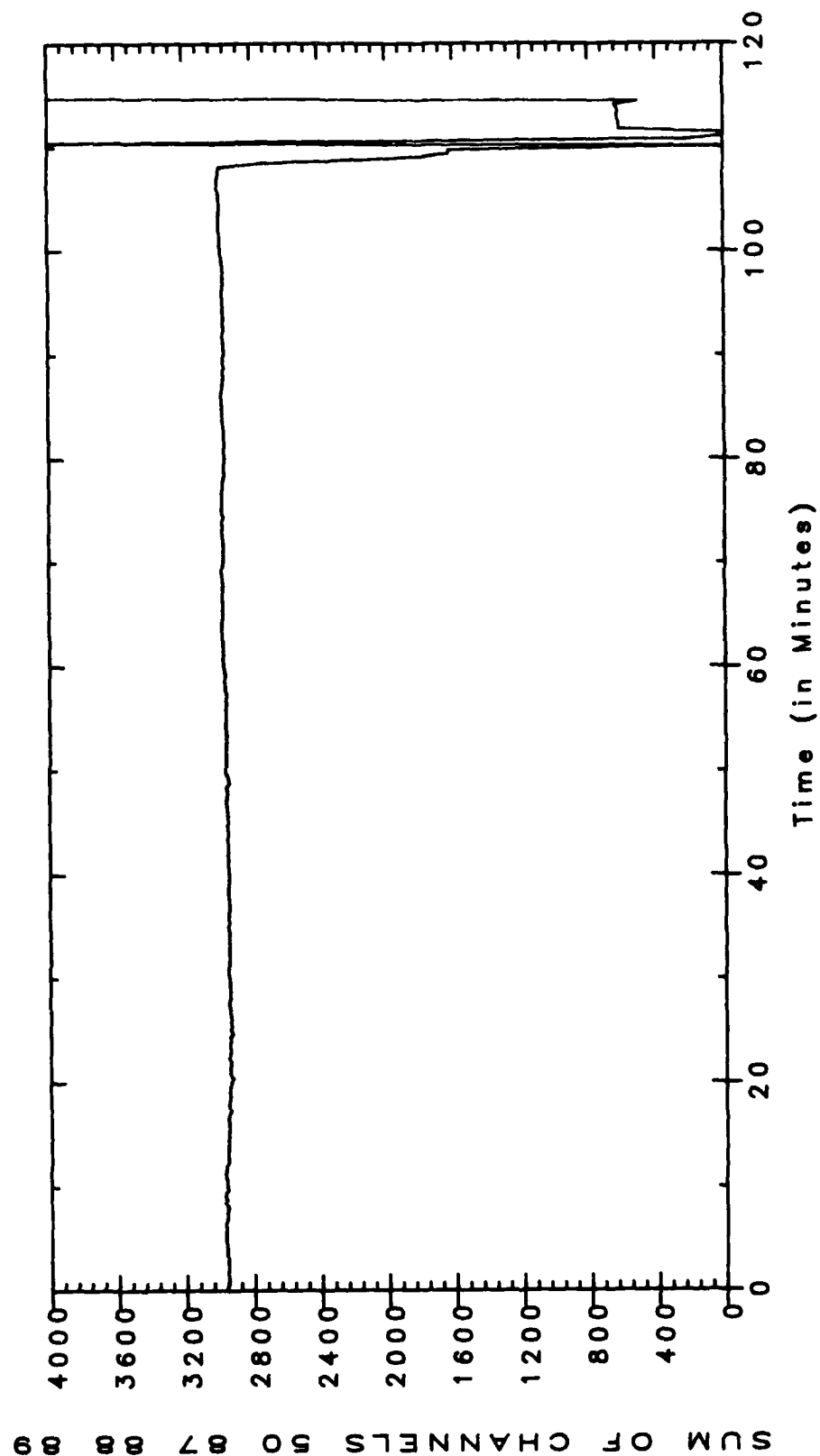


Test -11- Channel 55

HEAT FLUX DATA

RADIANT HEAT

TANK TESTS



Test -11- Channel 86

WEIGHT LOSS DATA
TEST TANK

TEST # 13

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 28 JUNE 1986

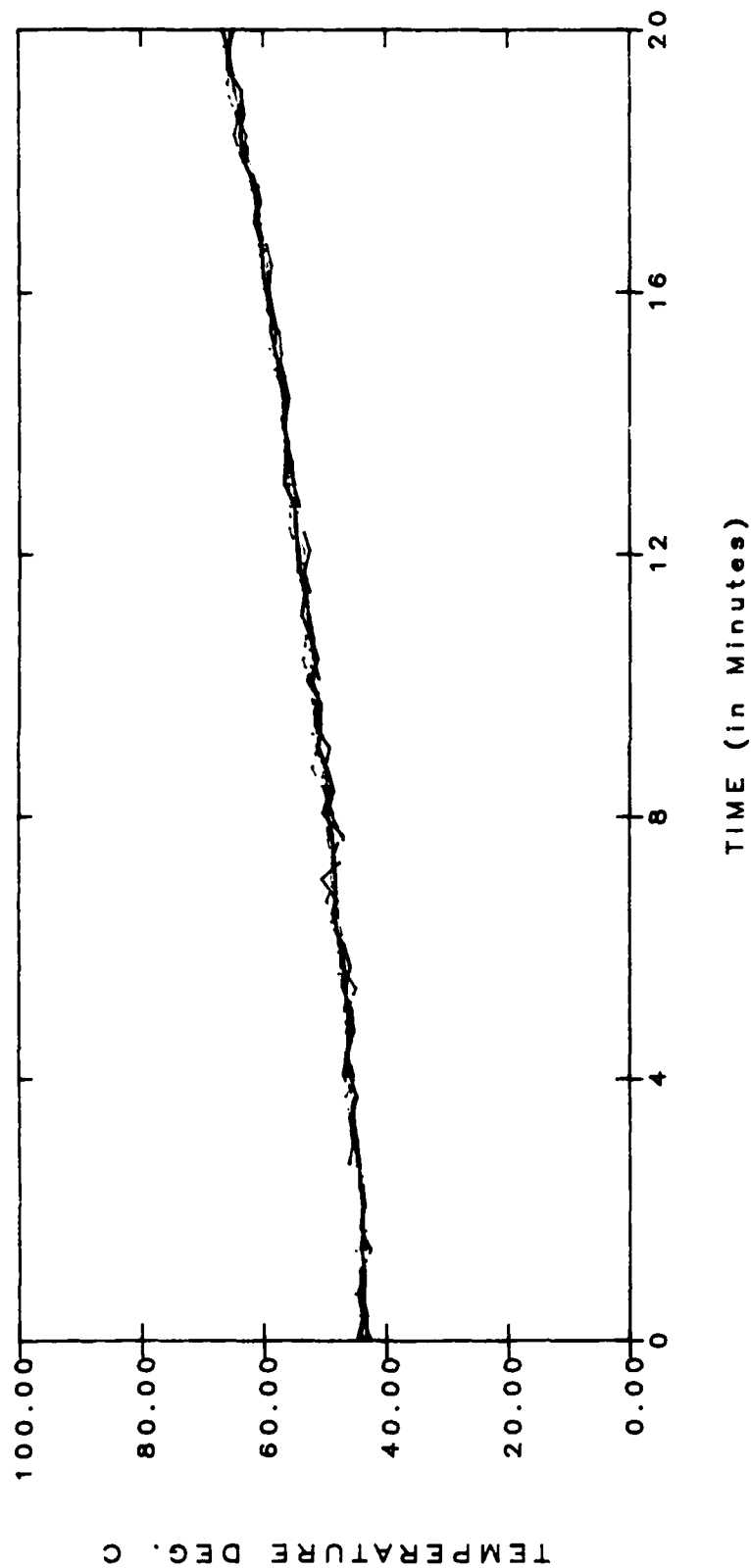
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:38:48 TANK VENTS - FIRE PLUME - SAFETY
00:39:37 LIQUID STOPS - VAPOR STILL BURNING
00:44:50 AFFF APPLICATION

CAMERA LOCATION: 03 DECK

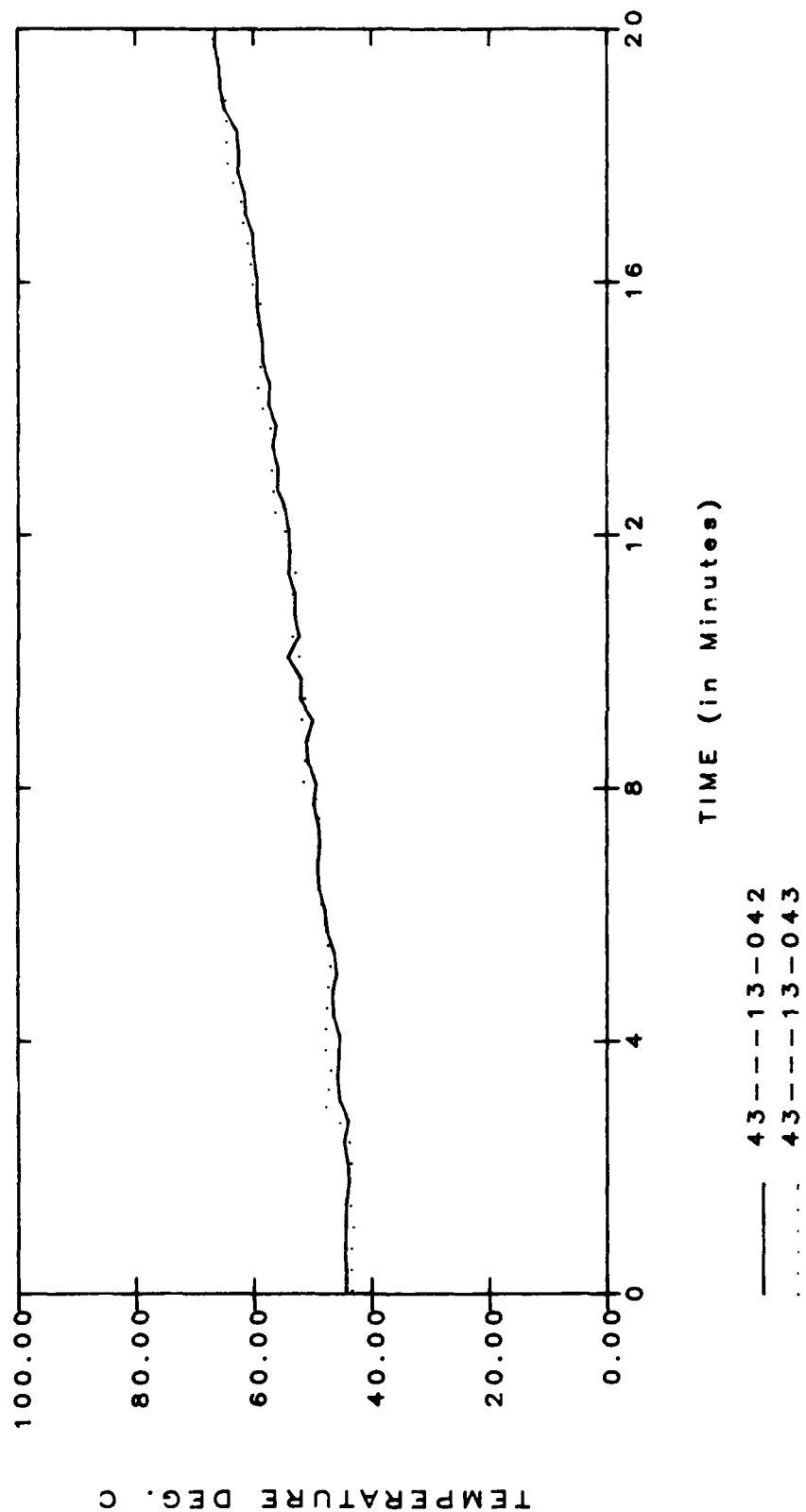
00:38:48 VENTS
00:39:36 LIQUID STOPS - VAPOR STILL BURNING
00:44:50 AFFF APPLICATION

TANK TESTS



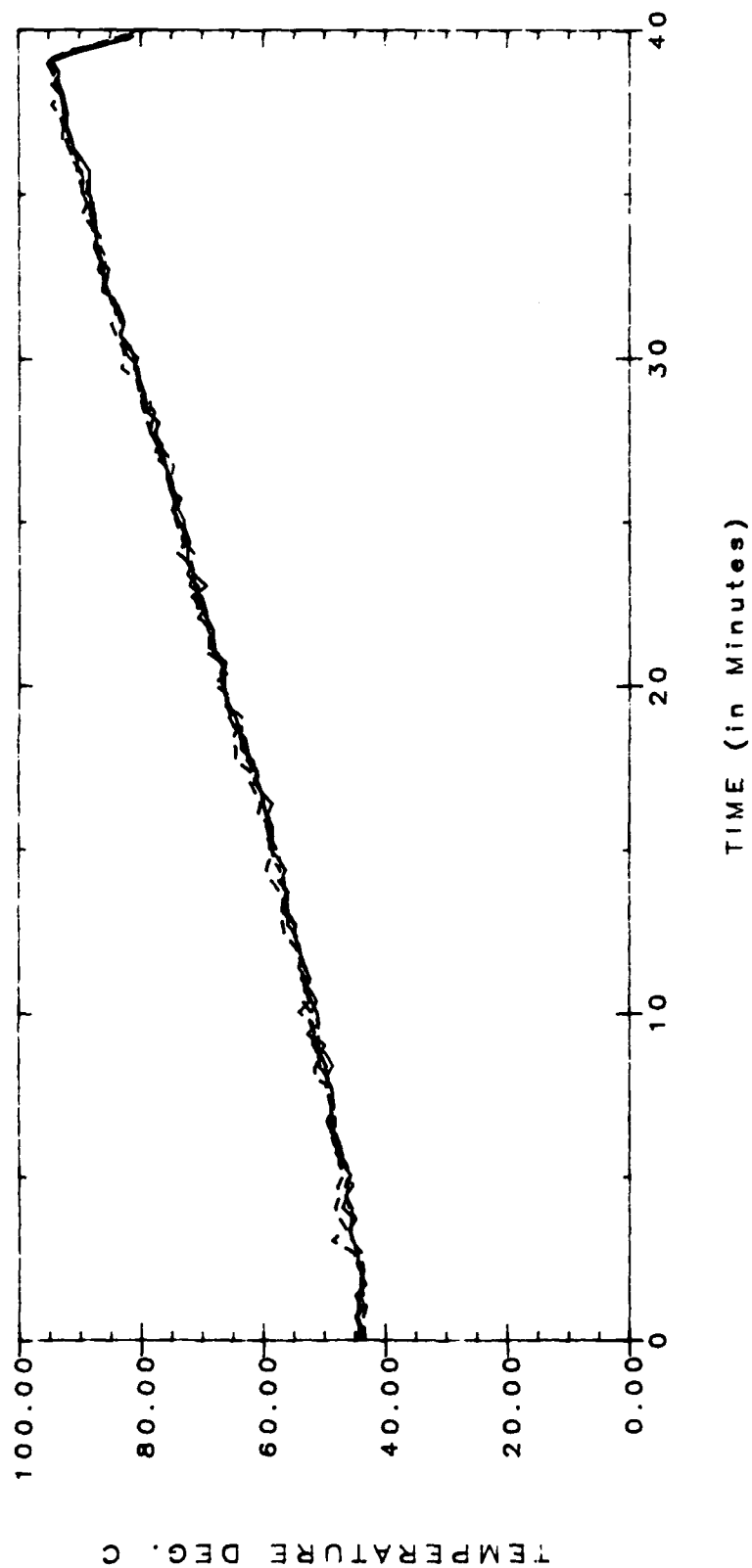
TIME/TEMPERATURE DATA

TANK TESTS



TIME/TEMPERATURE DATA

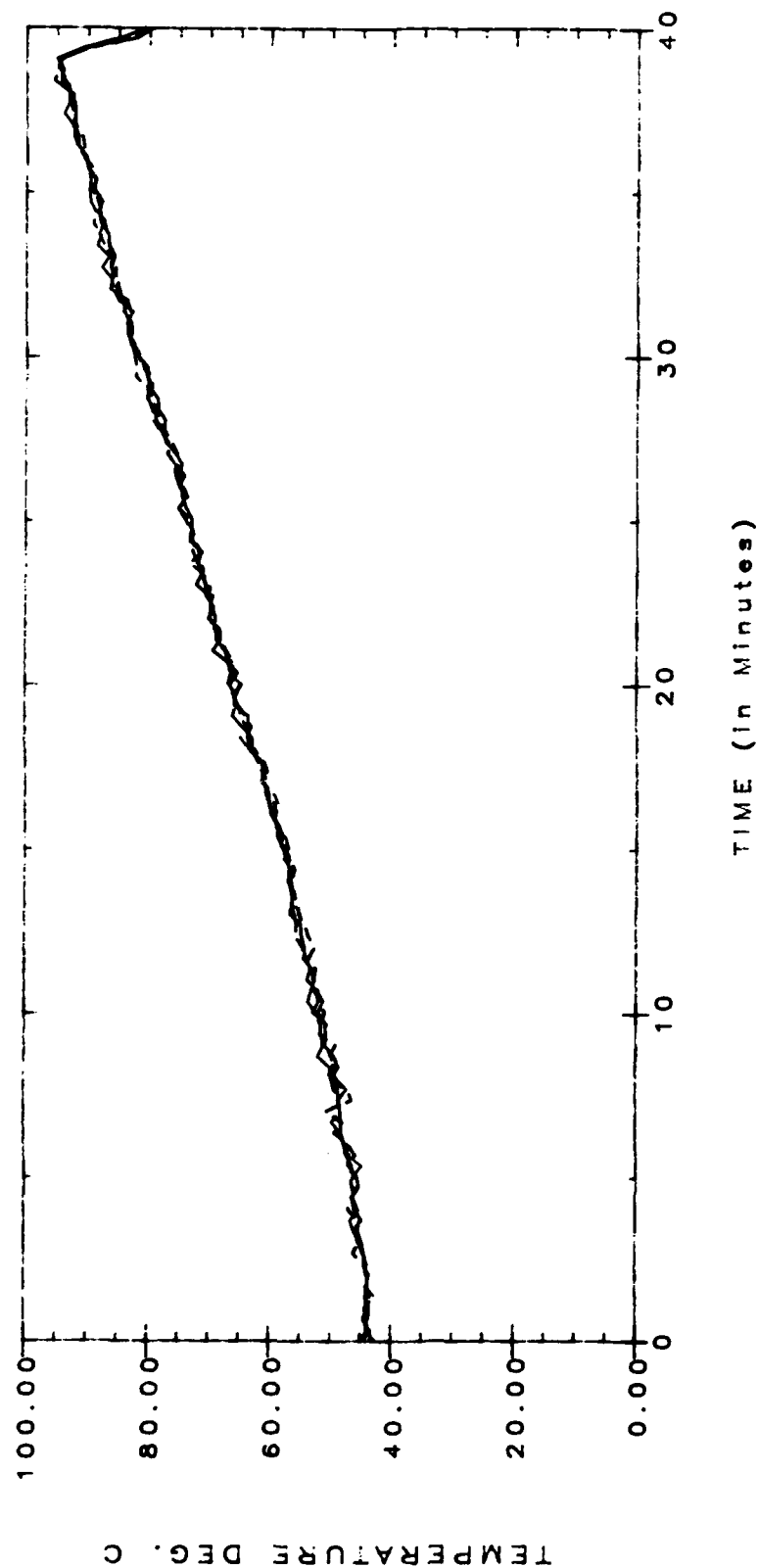
TANK TESTS



43---13-041
 43---13-042
 43---13-043
 43---13-044

TIME/TEMPERATURE DATA

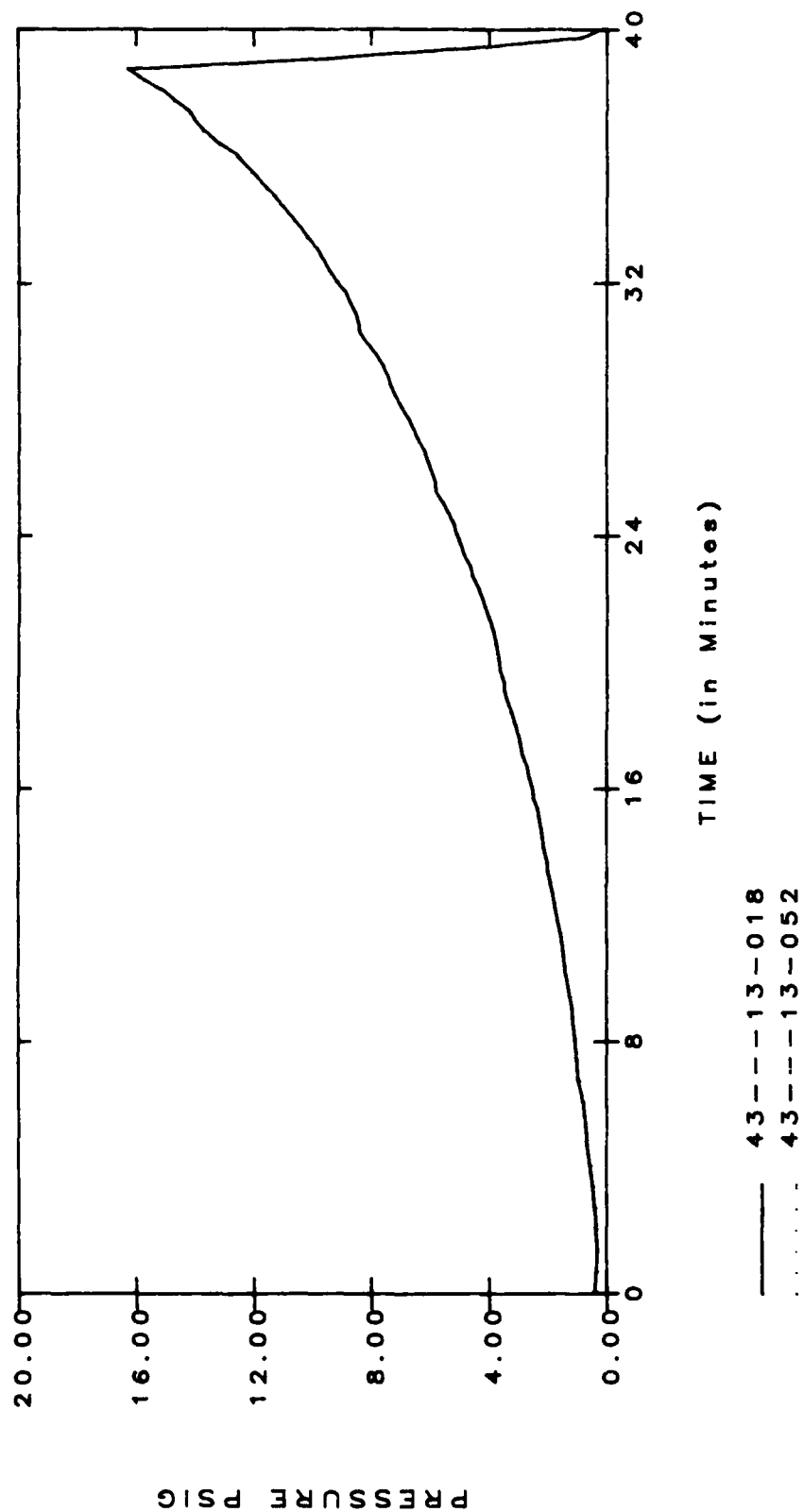
TANK TESTS



— 43-13-044
 — 43-13-045
 - - 43-13-047
 — 43-13-048

TIME/TEMPERATURE DATA

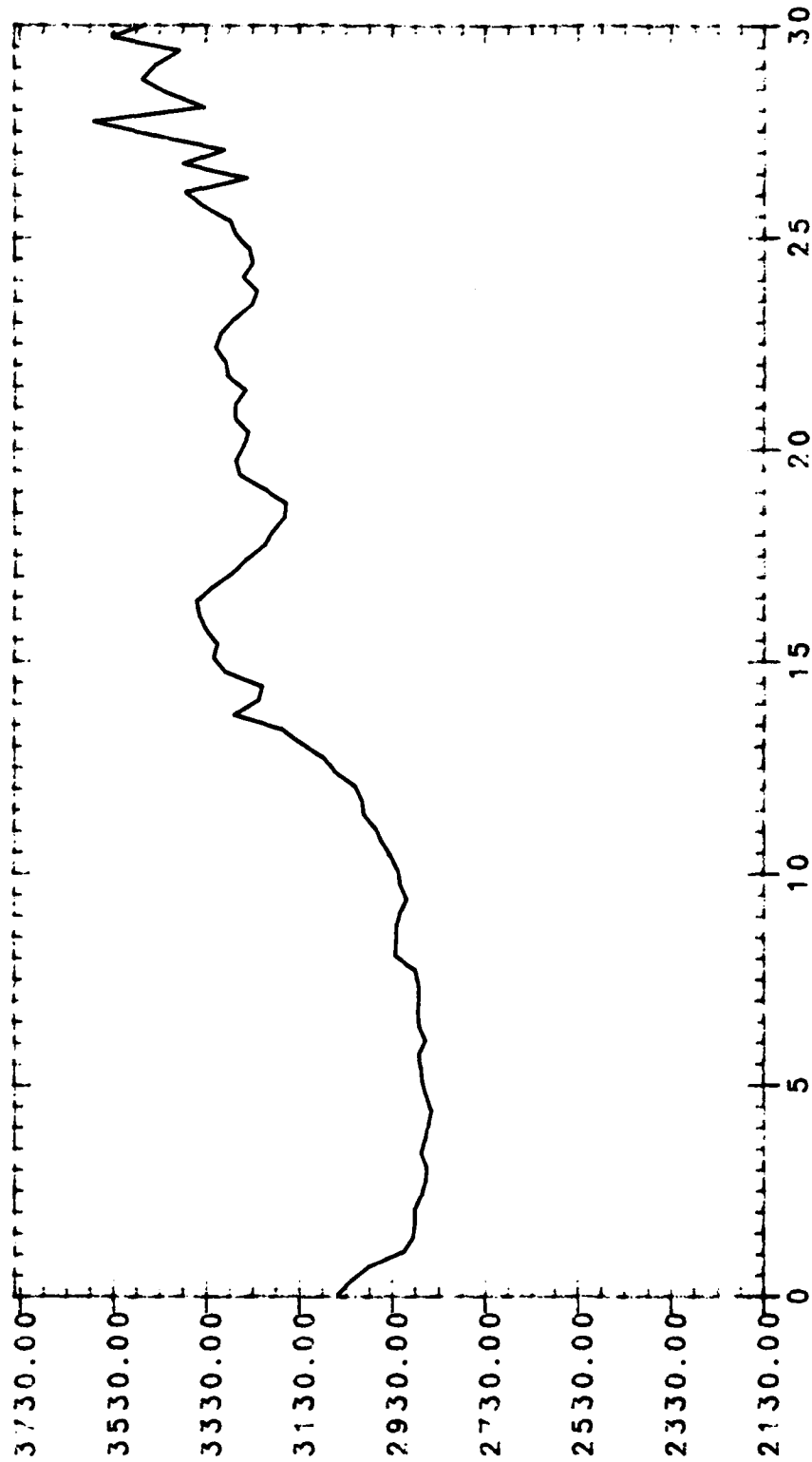
TANK TESTS



IN-TANK PRESSURE DATA

380.00
360.00
340.00
320.00
300.00
280.00
260.00
240.00
220.00
200.00

TANK TESTS



Time (in Minutes)

Test -13-- Channel 50

WEIGHT LOSS DATA
TEST TANK

TEST # 14

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 10 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

01:23:49 TANK VENTS (TOP)
01:25:30 EXTINGUISHMENT BEGAN

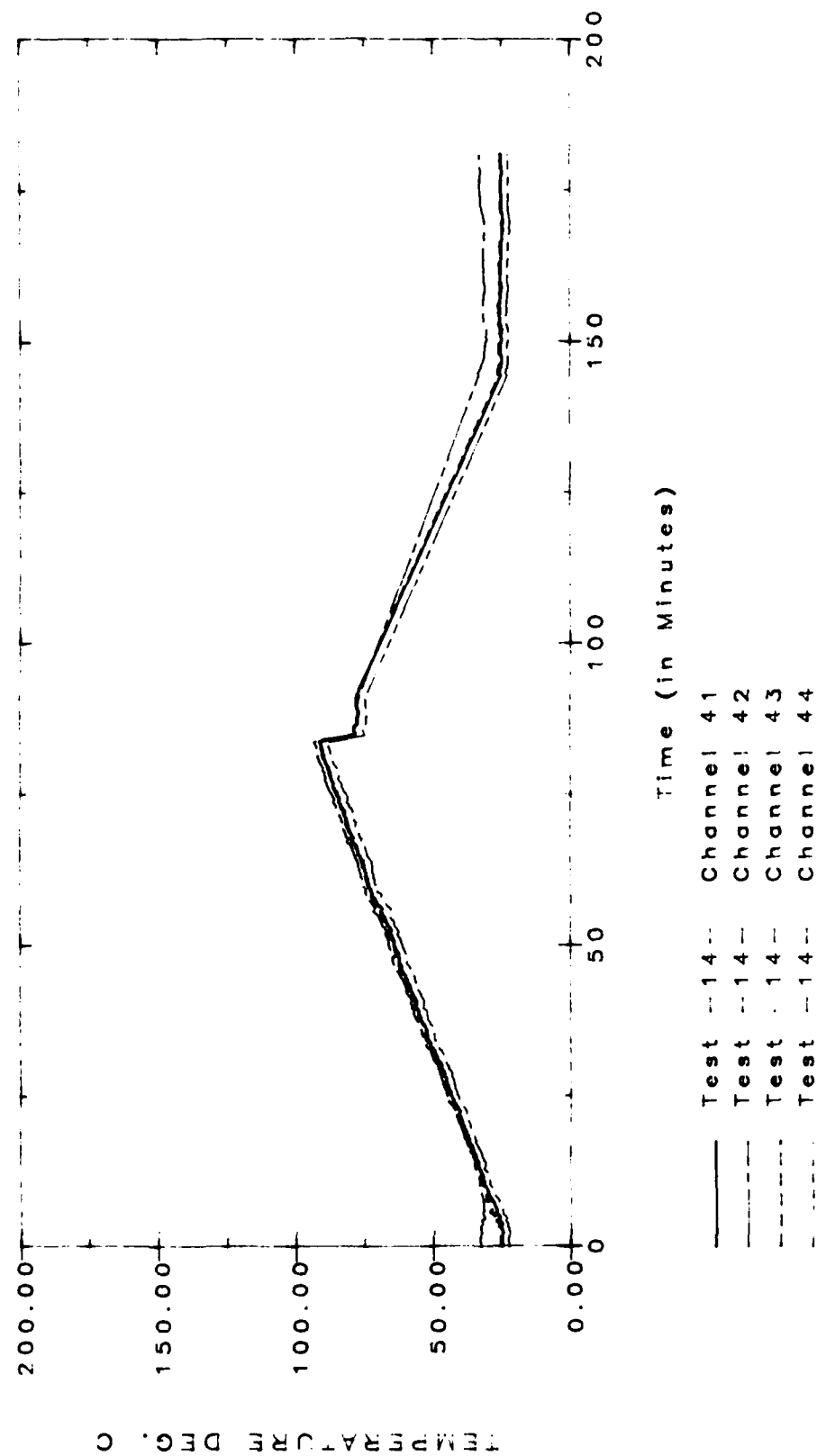
CAMERA LOCATION: 03 DECK

01:23:49 VENTS
01:25:33 EXTINGUISHMENT

CAMERA LOCATION: 04 DECK

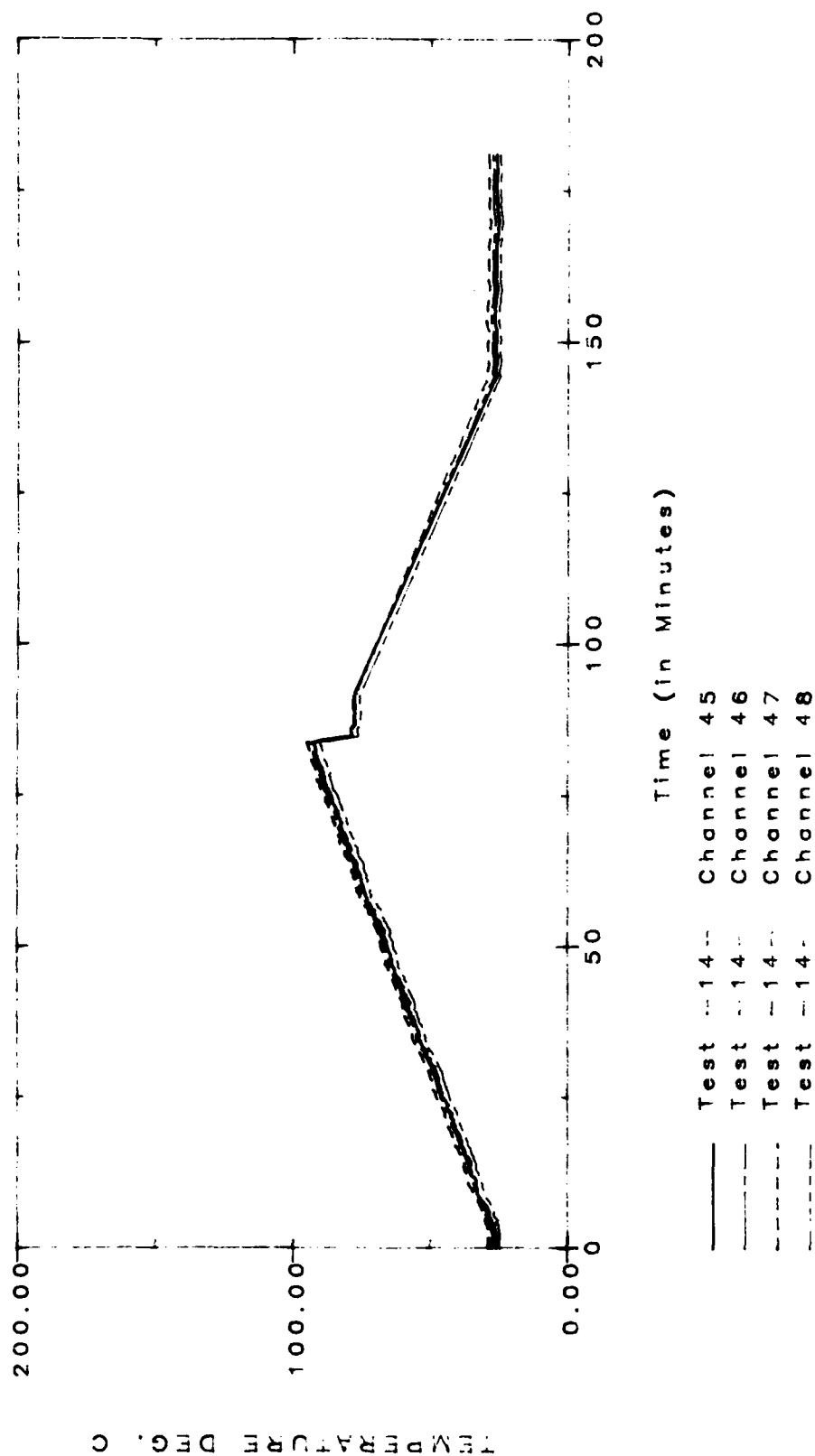
01:23:49 VENTS
01:25:33 EXTINGUISHMENT BEGAN

TANK TESTS



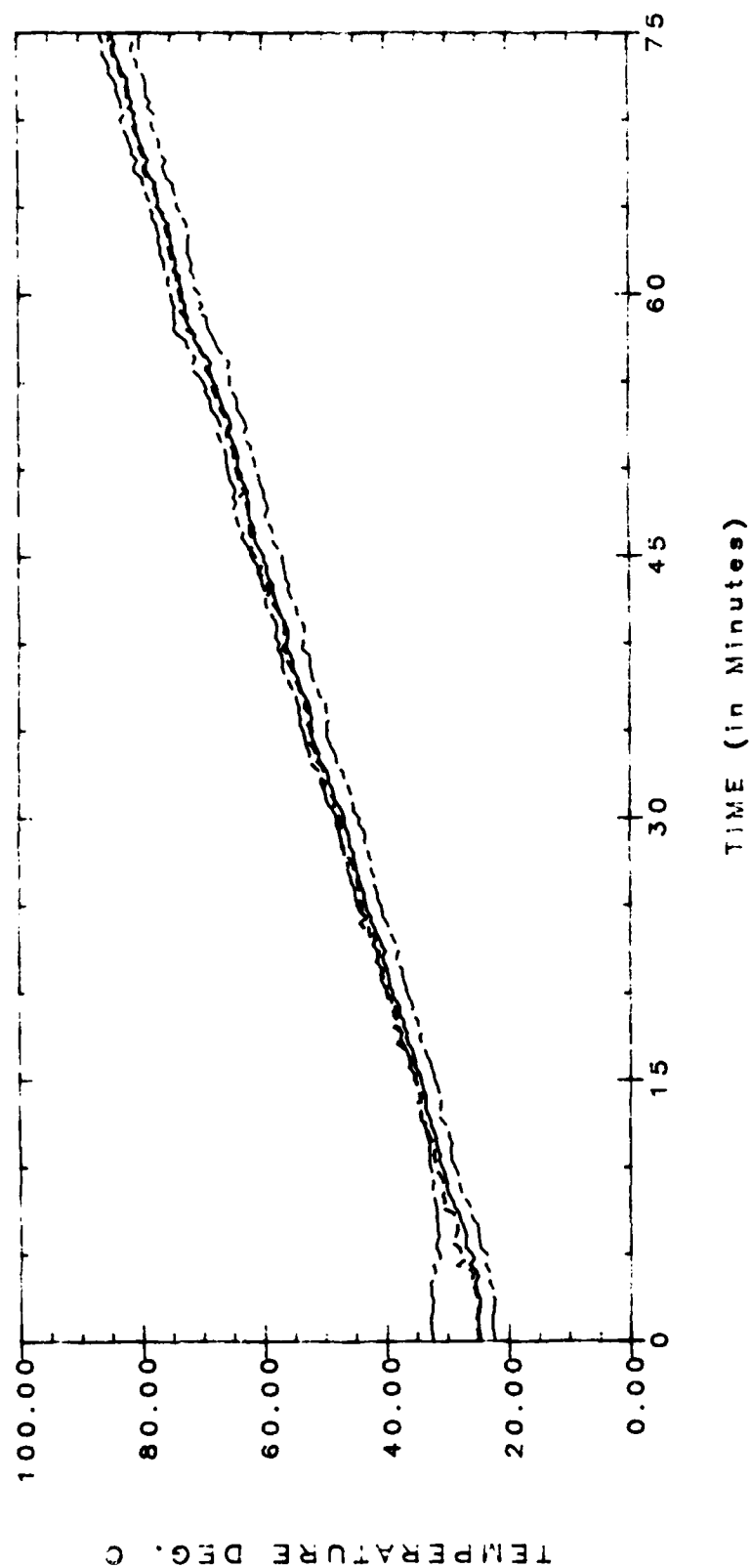
TIME/TEMPERATURE DATA

TANK TESTS



TIME/TEMPERATURE DATA

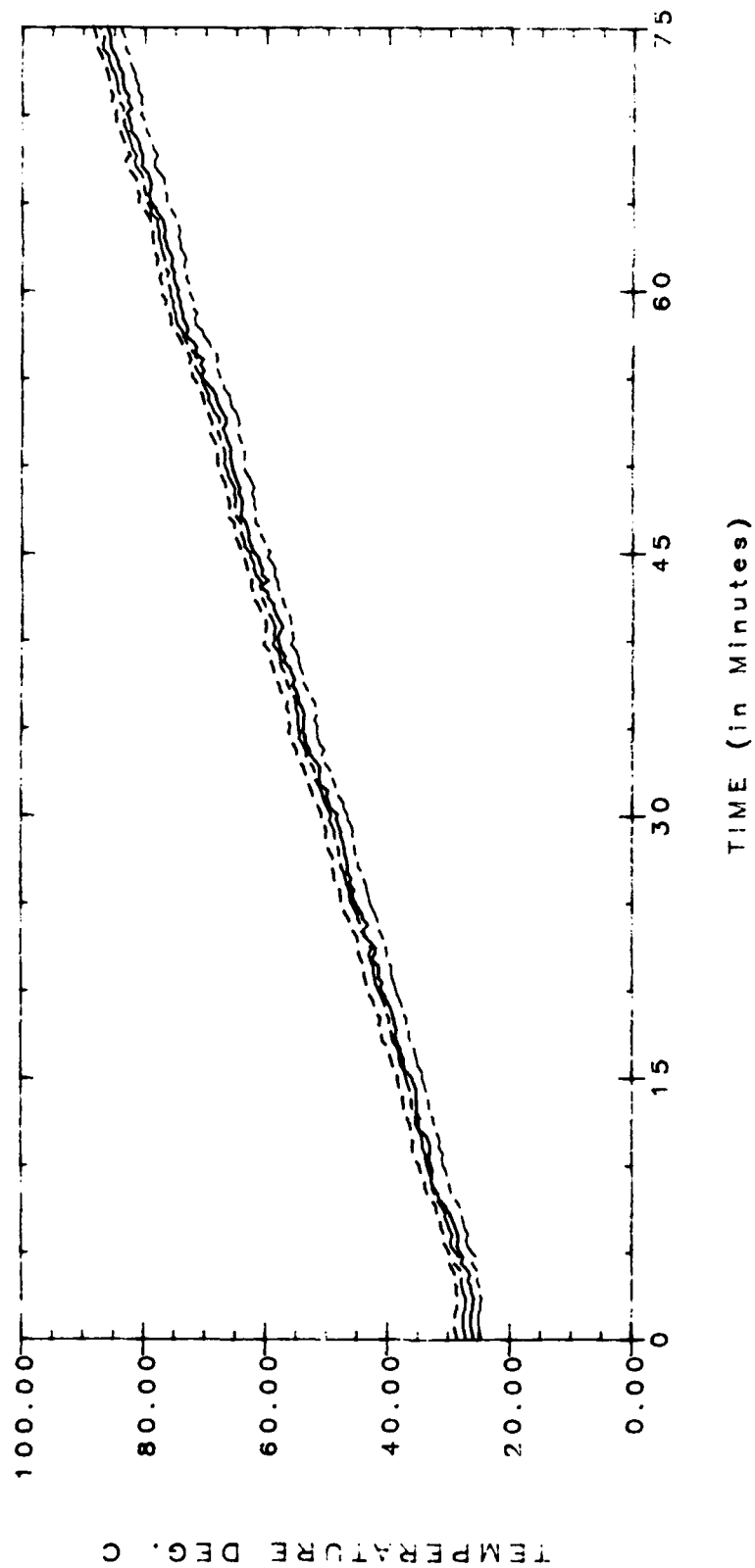
TANK TESTS



— 43.1-14-041
 — 43.1-14-042
 - - 43.1-14-043
 - - 43.1-14-044

TIME/TEMPERATURE DATA

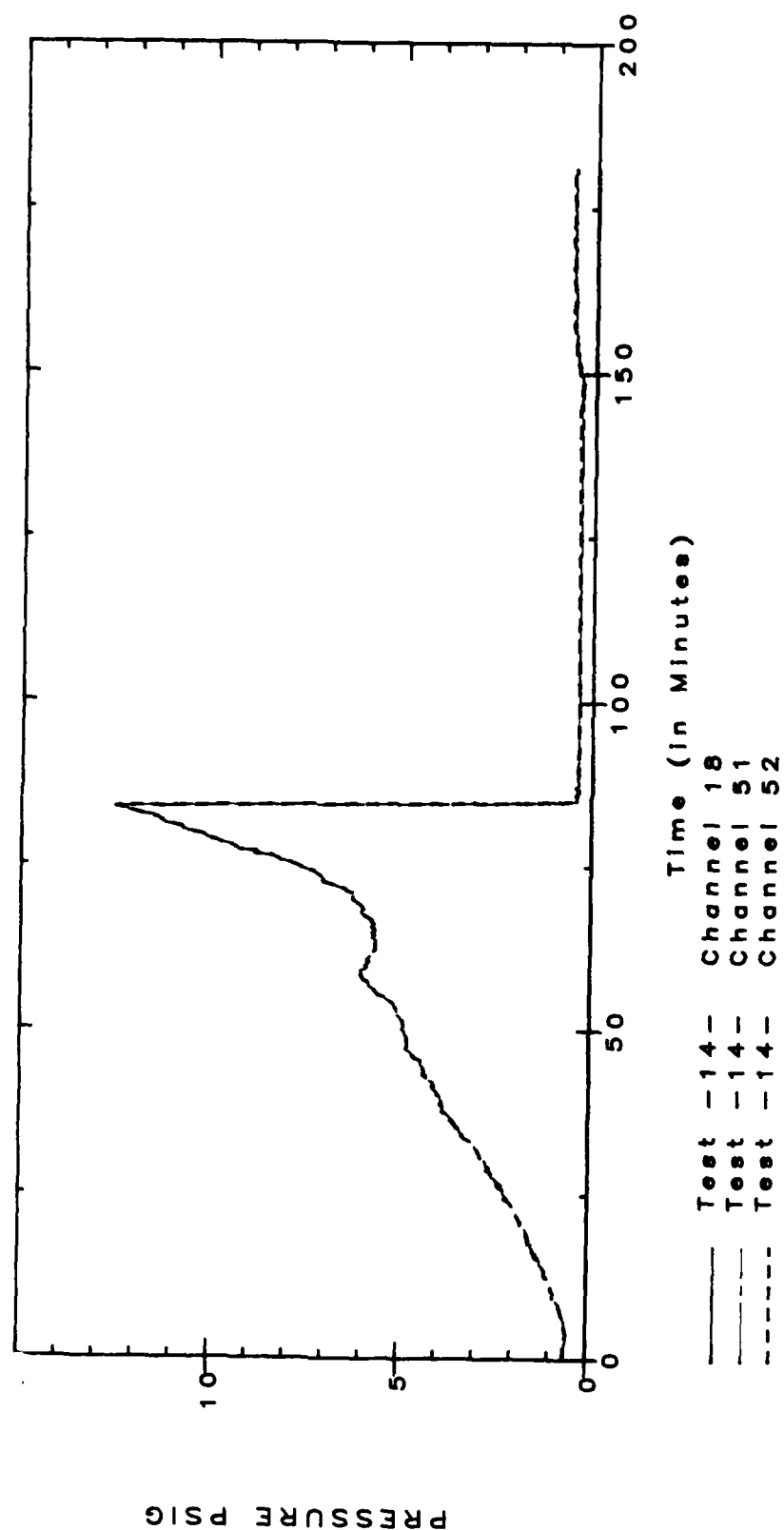
TANK TESTS



43.1-14-045
 43.1-14-046
 43.1-14-047
 43.1-14-048

TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

TEST # 15

TYPE OF TANK: STEEL TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 11 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

02:20:56 RELIEF GOES, RELEASES ETOH PLUME, NO VISIBLE FIRE

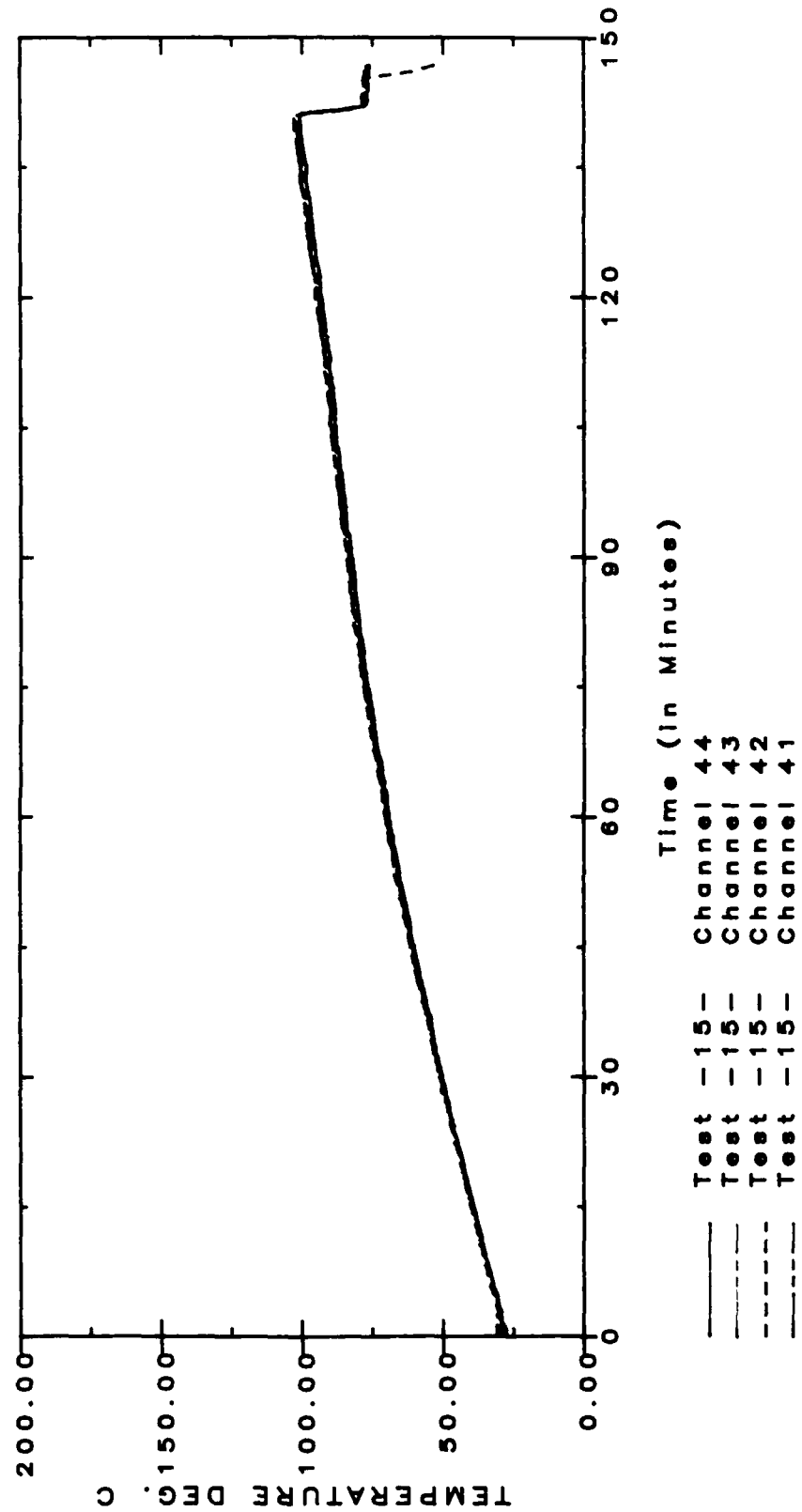
CAMERA LOCATION: 03 DECK

02:20:55 RELIEF FAILED - ETOH RELEASED, NO VISIBLE FIRE

CAMERA LOCATION: 04 DECK

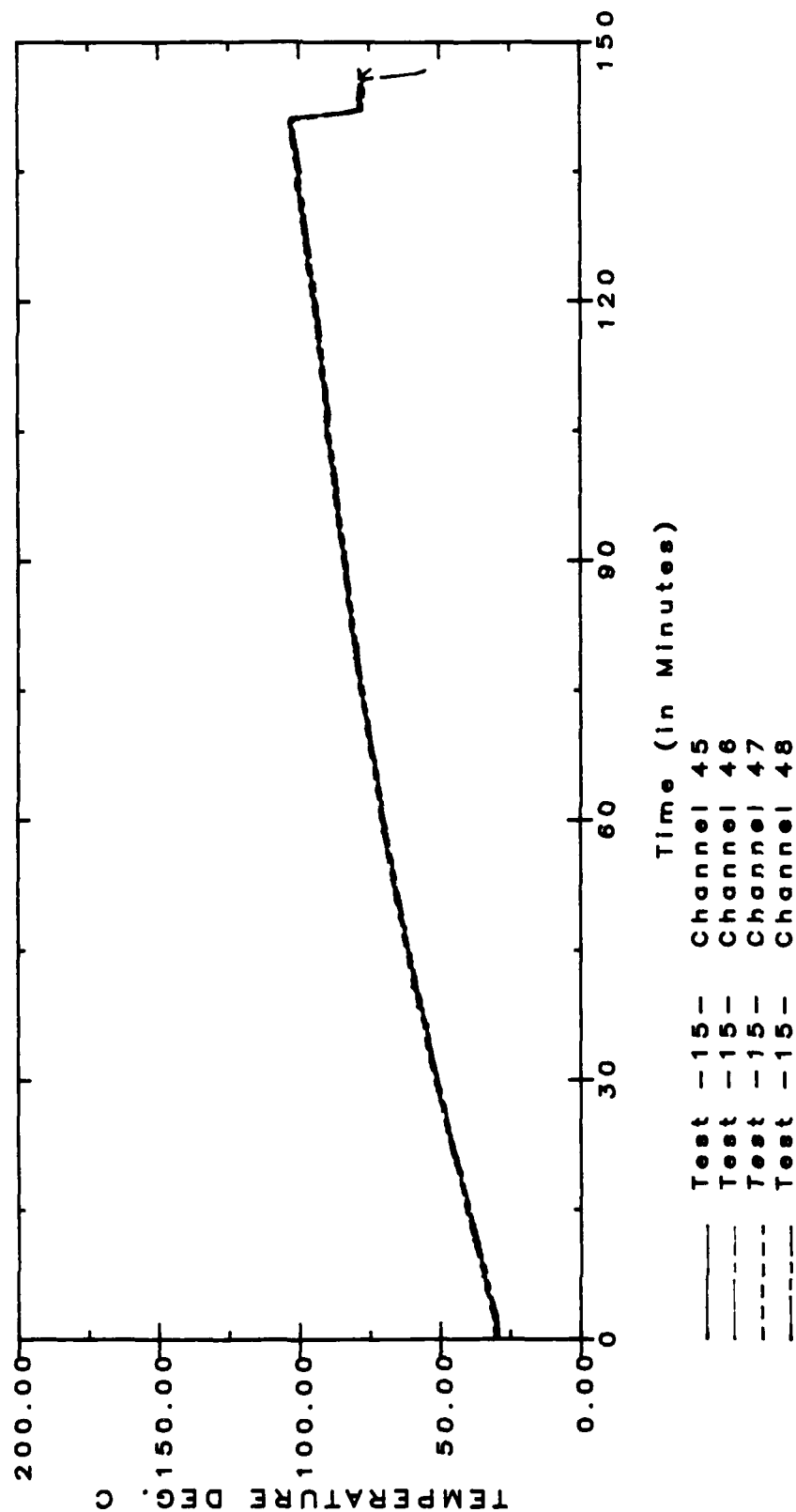
02:20:55 RELIEF VALVE GOES - ETOH RELEASED, NO VISIBLE FIRE

TANK TESTS



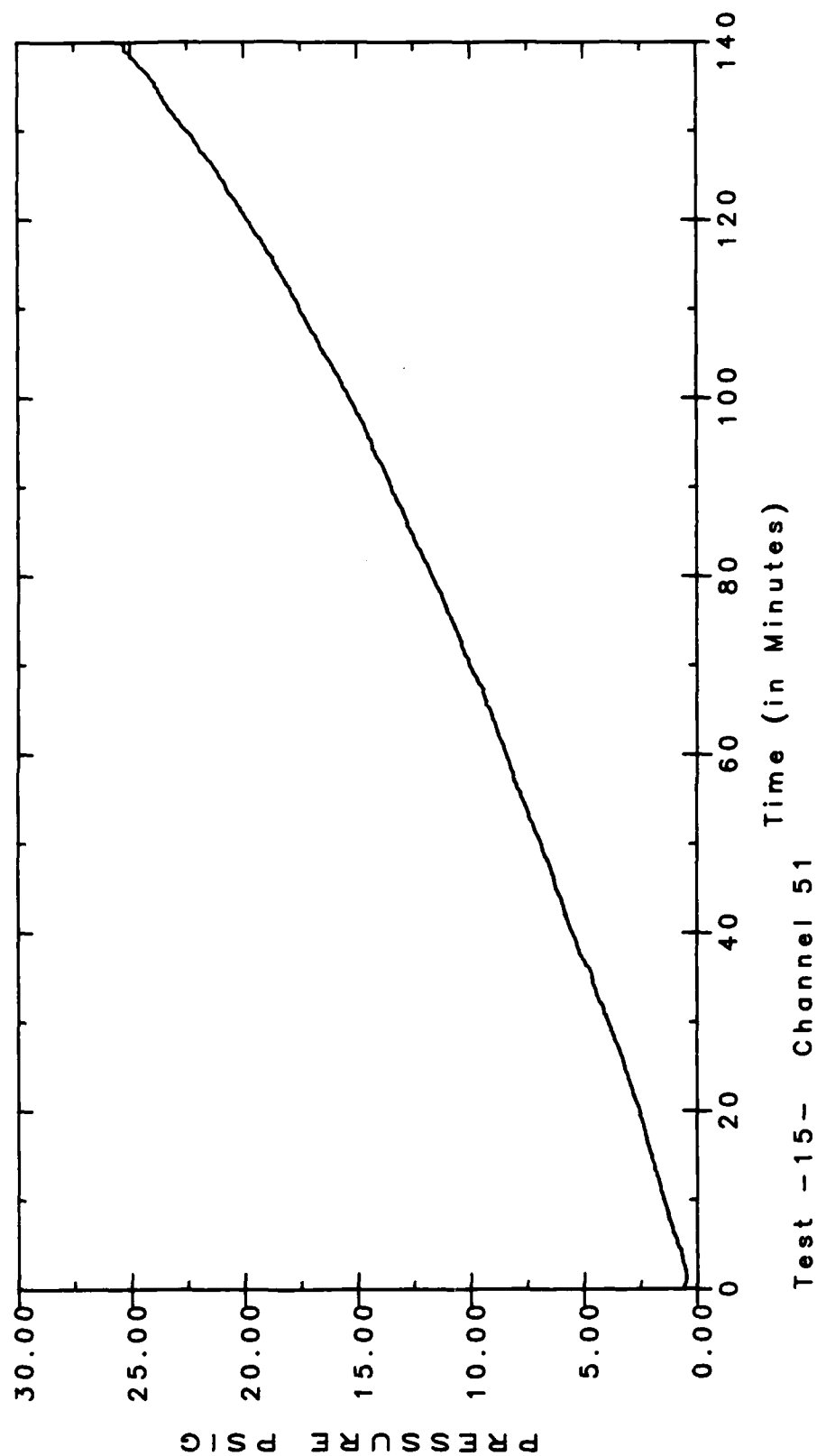
TIME/TEMPERATURE DATA

TANK TESTS



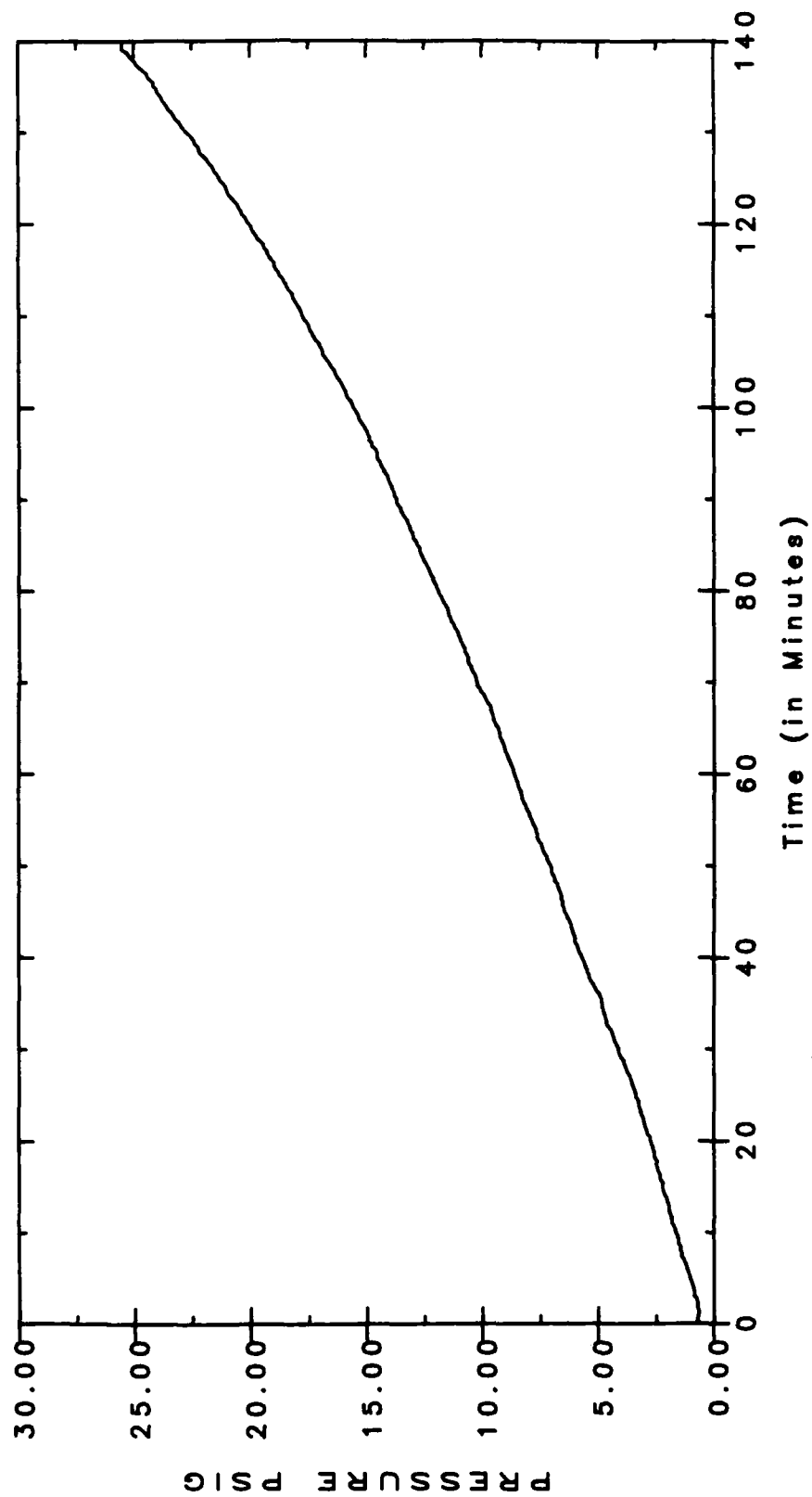
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

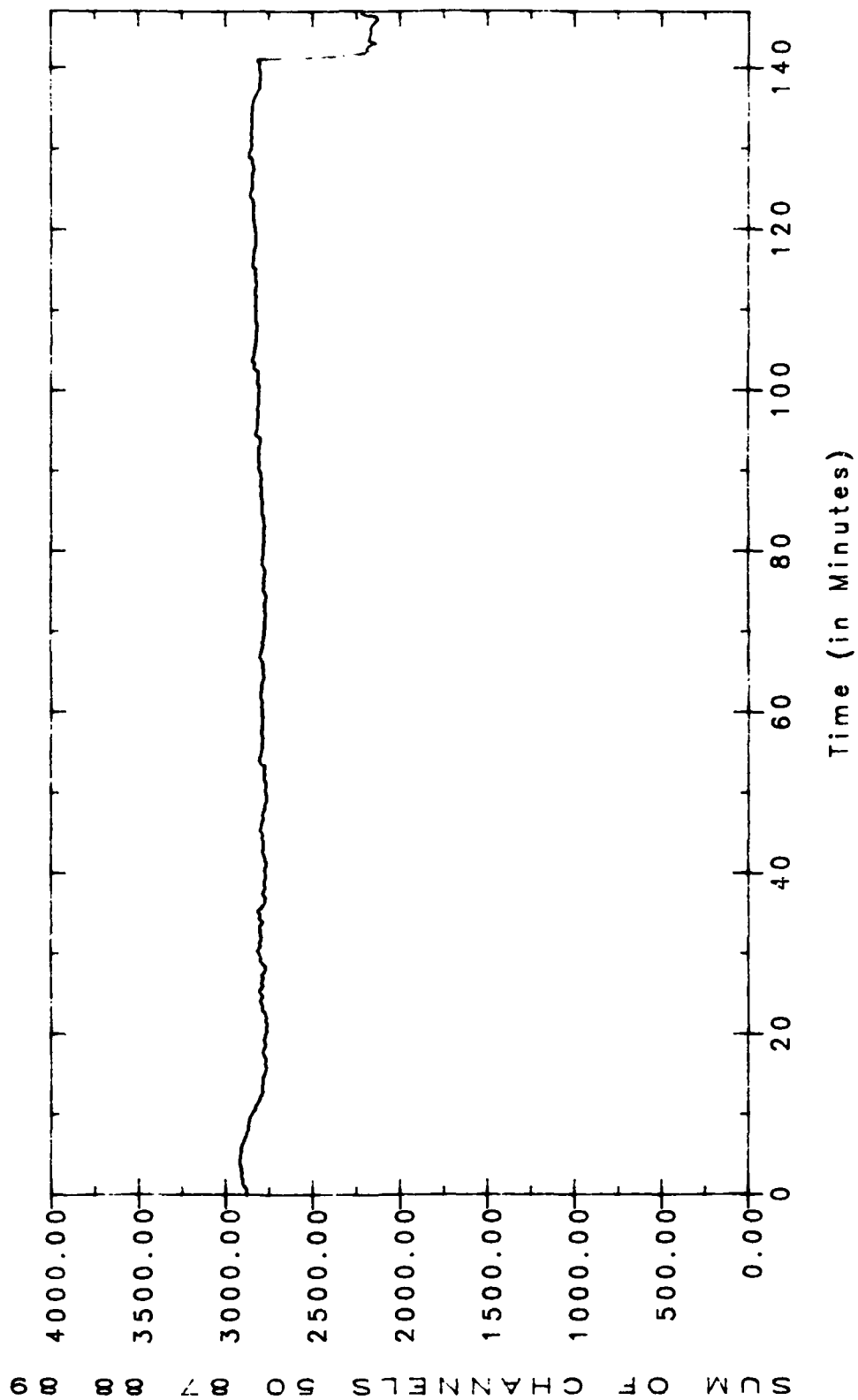
TANK TESTS



Test -15- Channel 52

IN-TANK PRESSURE DATA

TANK TESTS



Test -15- Channel 86

WEIGHT LOSS DATA
TEST TANK

TEST # 16

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 25 JUNE 1986

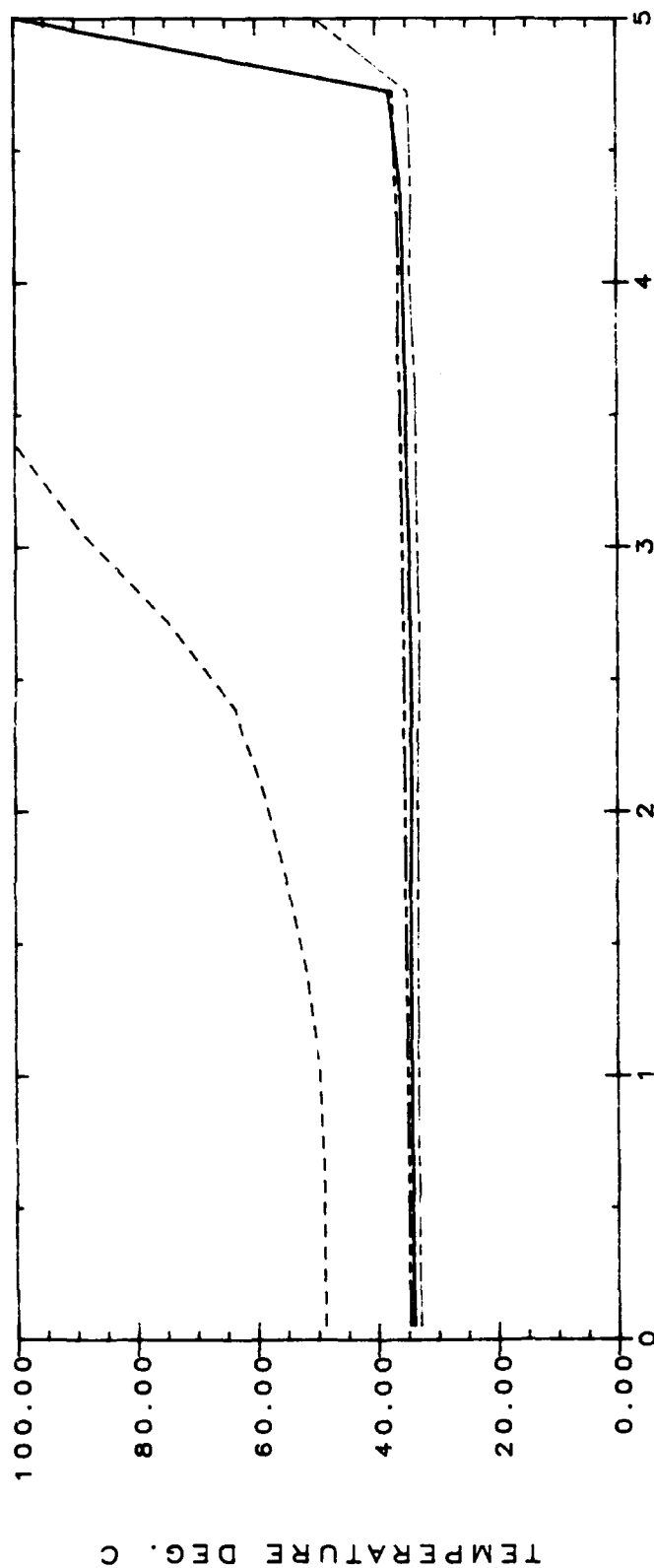
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:47 CAN'T TELL WHEN FAILURE OCCURRED
00:05:23 TOP BEGINNING TO GIVE
00:05:23 TOP OF TANK GONE
00:07:46 CO2 APPLICATION, FIRE NOT CONTROLLED
00:10:31 AFFF APPLICATION
00:10:50 FIRE UNDER CONTROL
00:15:00 REKINDLED

CAMERA LOCATION: 03 DECK

00:10:31 TANK OBSCURED BY FLAMES
00:10:31 CO2 APPLICATION
00:10:31 FLAMES OBSCURING CO2 APPLICATION
00:10:31 FIRE NOT CONTROLLED
00:10:31 AFFF APPLICATION
00:10:50 FIRE UNDER CONTROL
00:15:00 REKINDLED

TANK TESTS

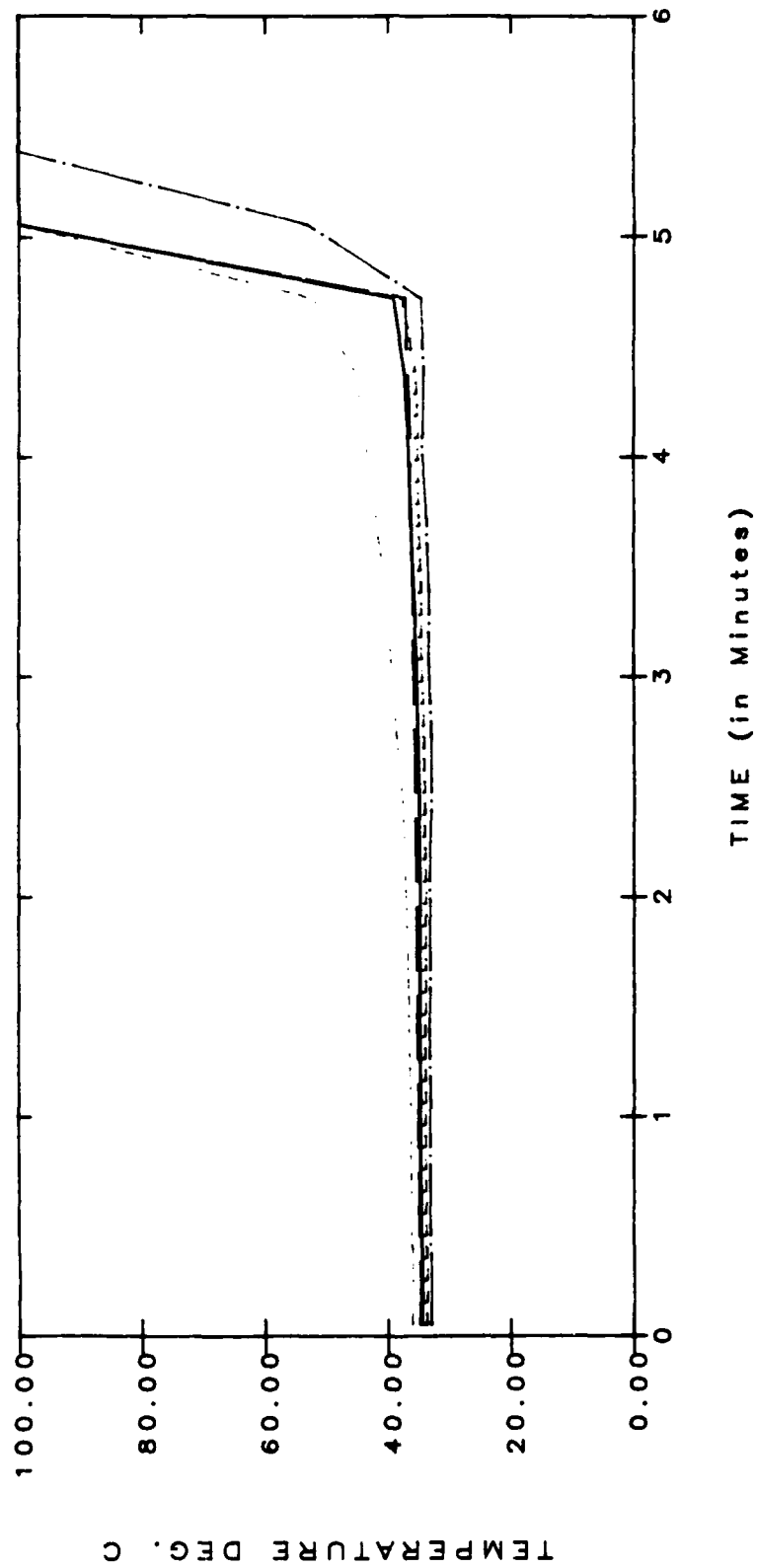


Time (in Minutes)

—	Test -16-	Channel 44
- - -	Test -16-	Channel 43
- . - . -	Test -16-	Channel 42
- . - . -	Test -16-	Channel 41

TIME/TEMPERATURE DATA

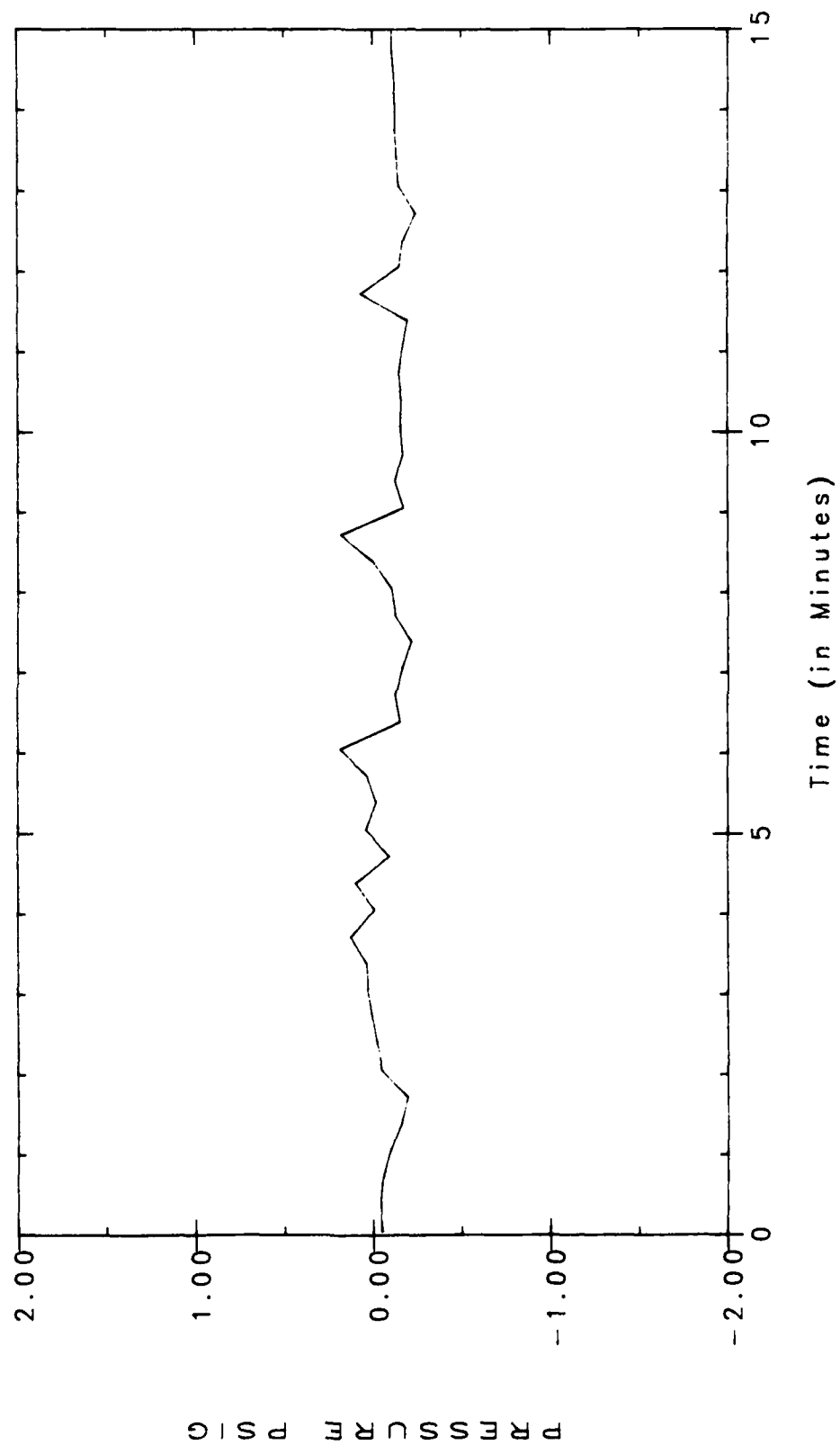
TANK TESTS



43- - - - 16-045
 43- - - - 16-046
 43- - - - 16-047
 43- - - - 16-048
 43- - - - 16-041
 43- - - - 16-043

TIME/TEMPERATURE DATA

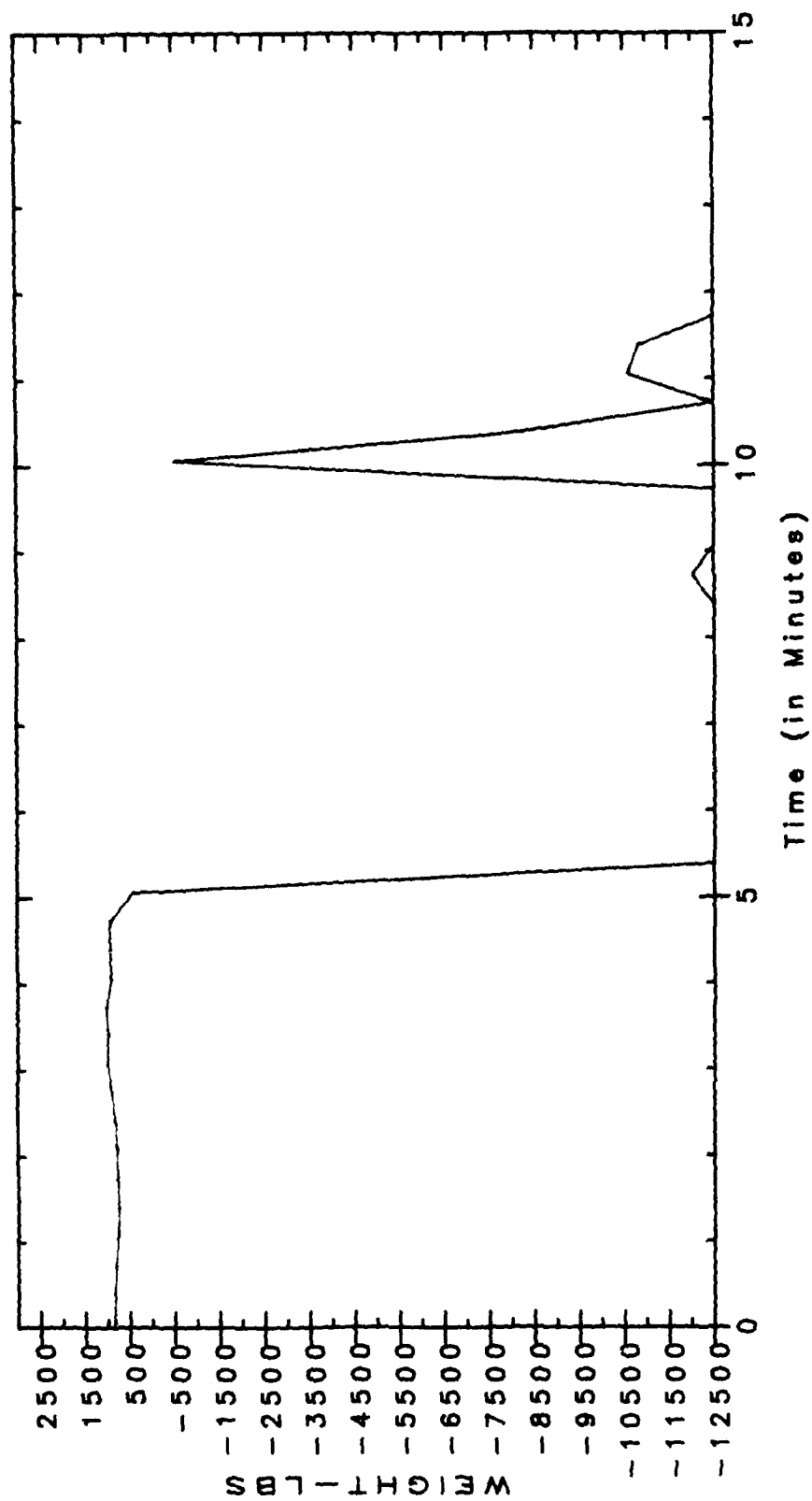
TANK TESTS



Test -16- Channel 51

IN-TANK PRESSURE DATA

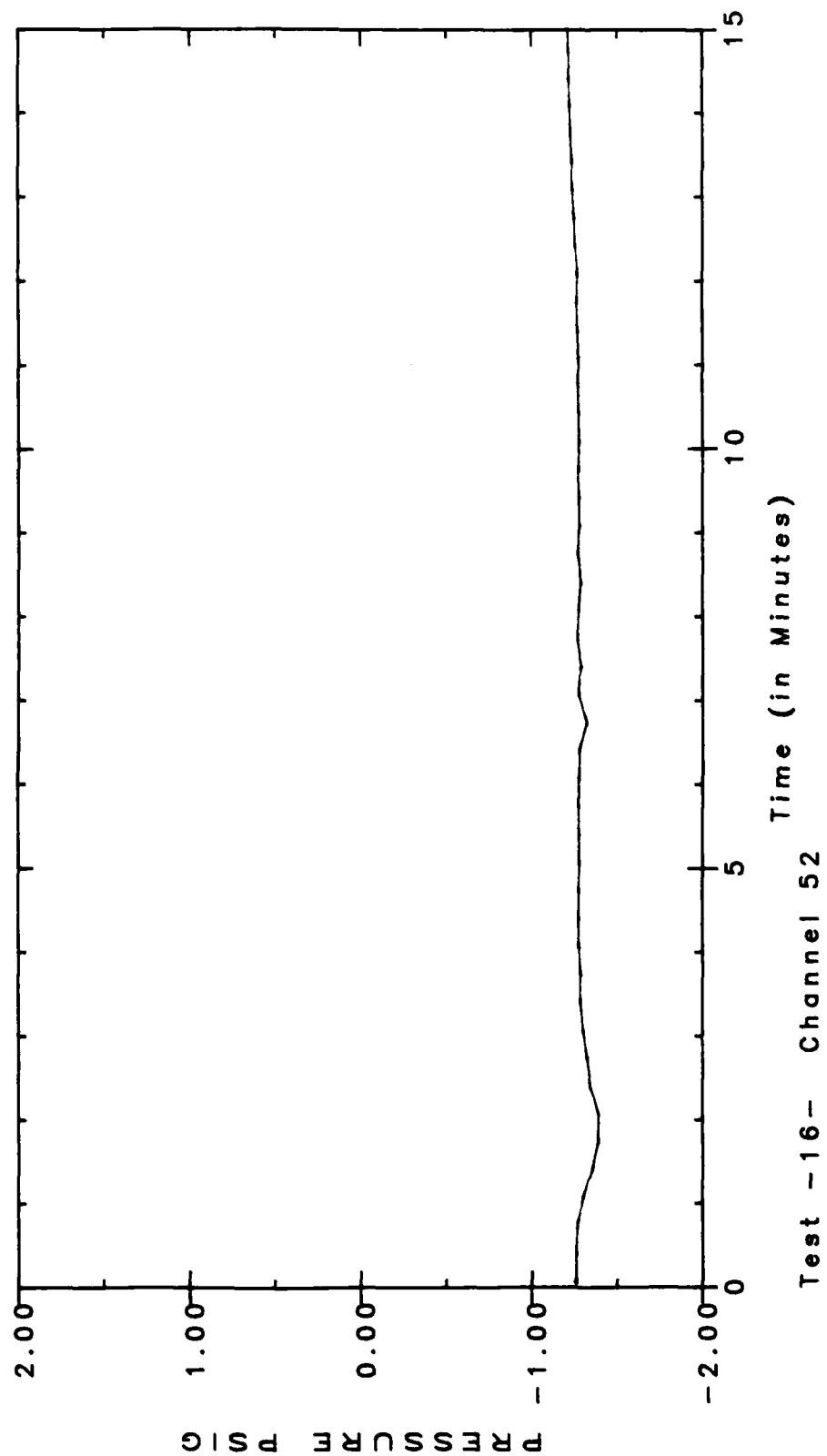
TANK TESTS



Test -16- Channel 50

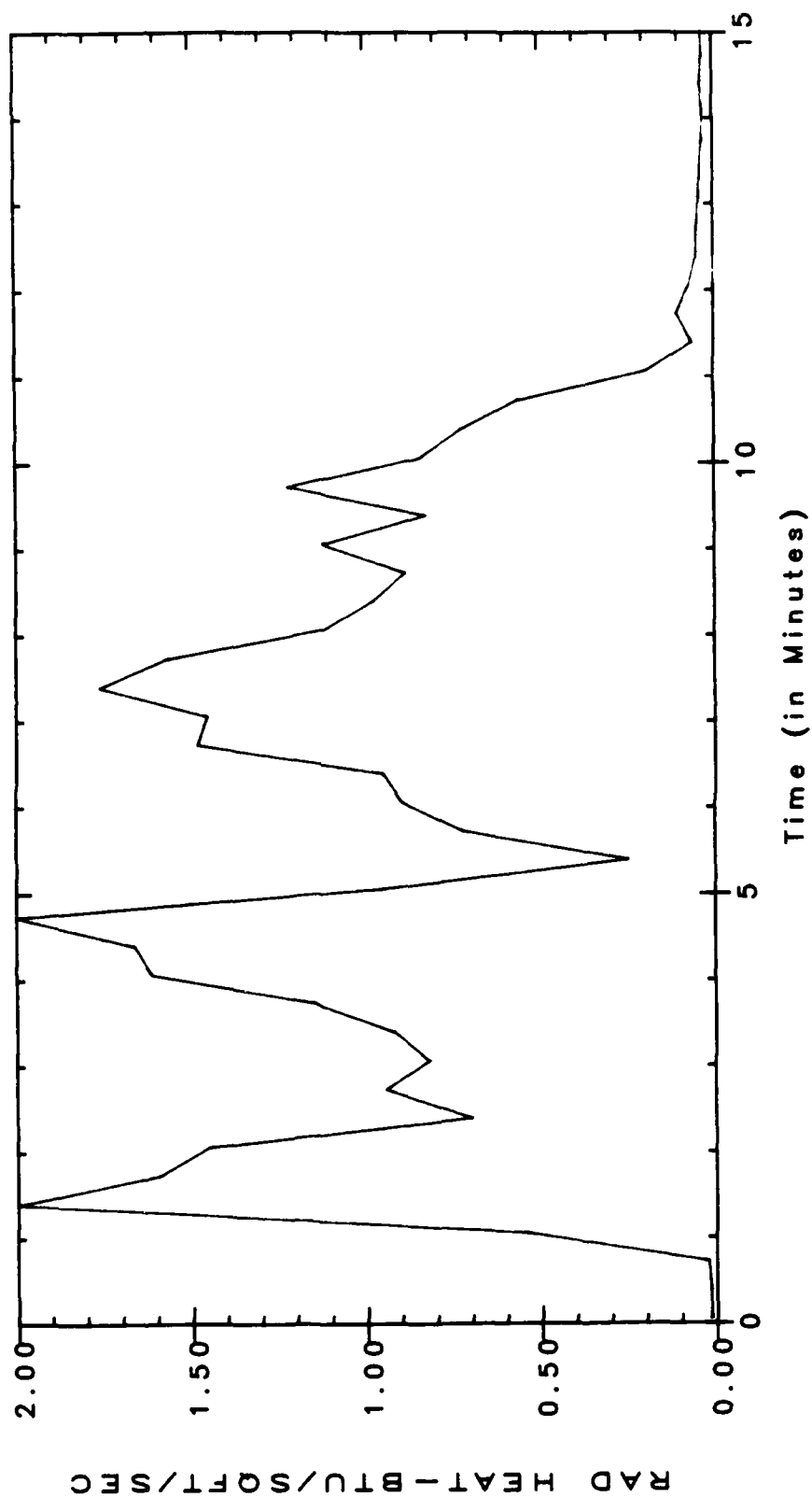
WEIGHT LOSS DATA
TEST TANK

TANK TESTS



IN-TANK PRESSURE DATA

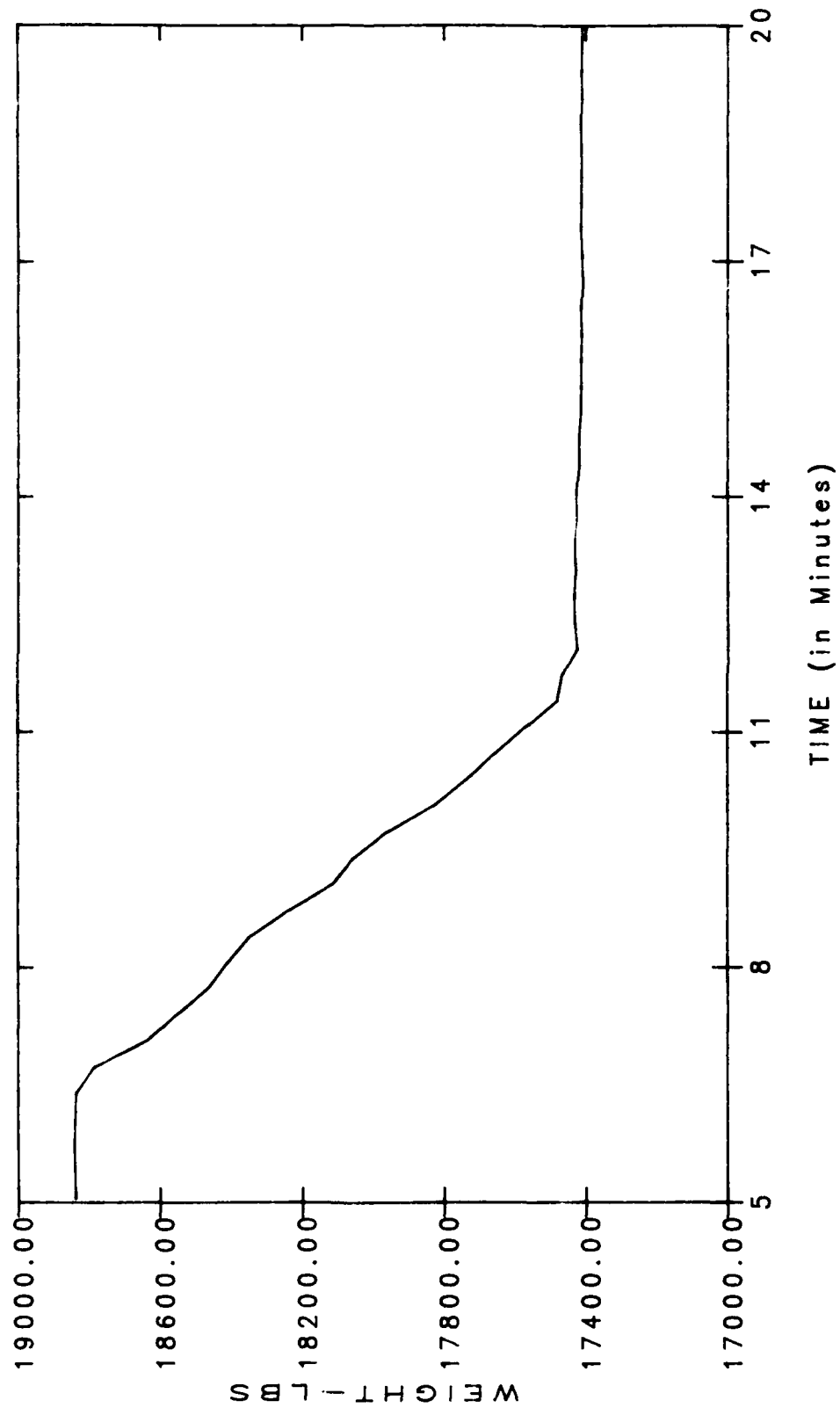
TANK TESTS



Test -16- Channel 54

HEAT FLUX DATA
RADIANT HEAT

TANK TESTS



43--16-049

WEIGHT LOSS DATA
CARDOX TANK

TEST # 17

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 15 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:03:54 TANK FAILED?
00:06:17 EXTINGUISHMENT
00:07:18 FIRE OUT

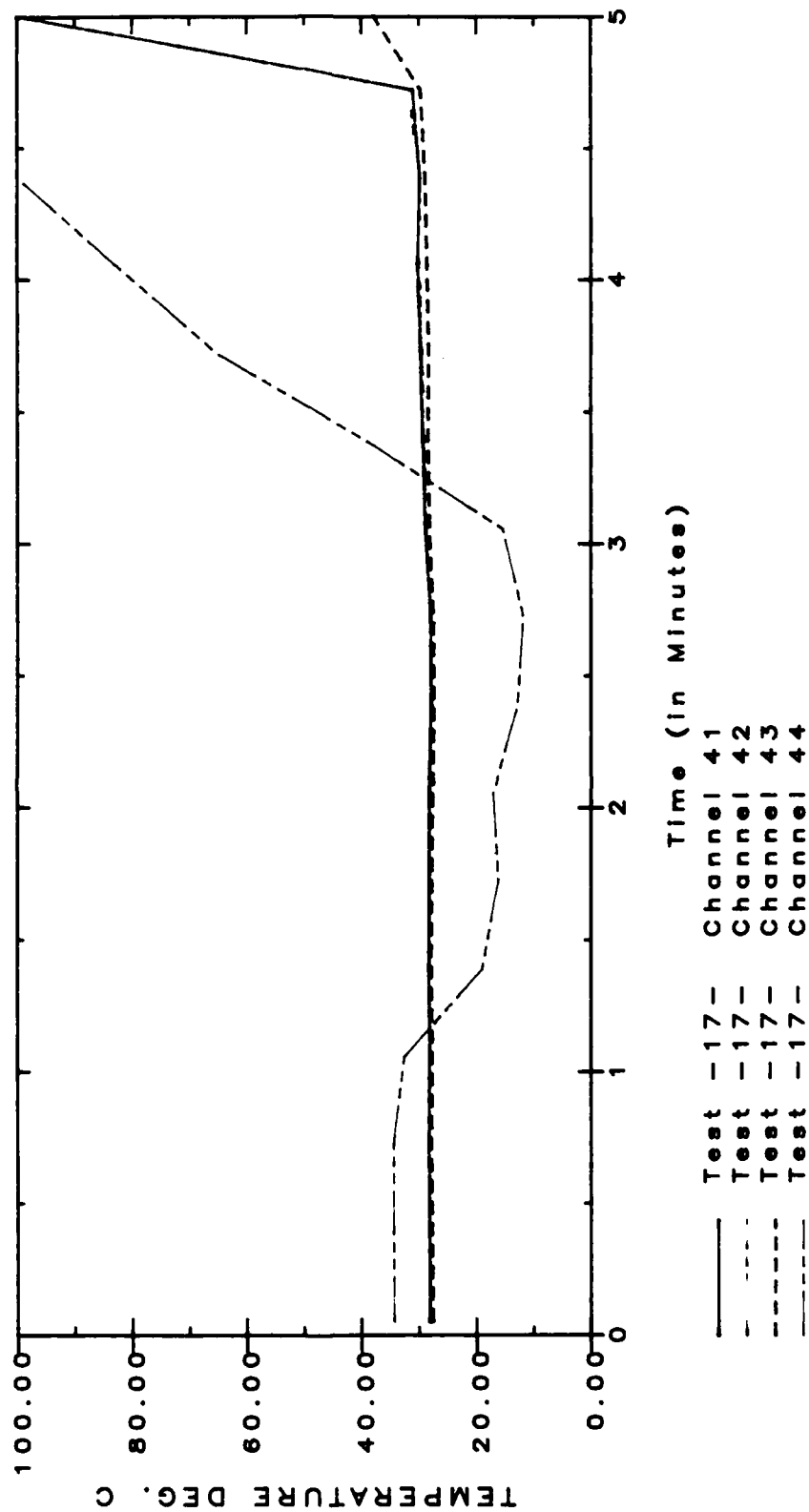
CAMERA LOCATION: 03 DECK

00:03:40 COLLAPSE (VOICE PER B. MCLAIN ON TAPE)
00:04:10 TANK FAILURE (VOICE)
00:06:17 EXTINGUISHMENT

CAMERA LOCATION: 04 DECK

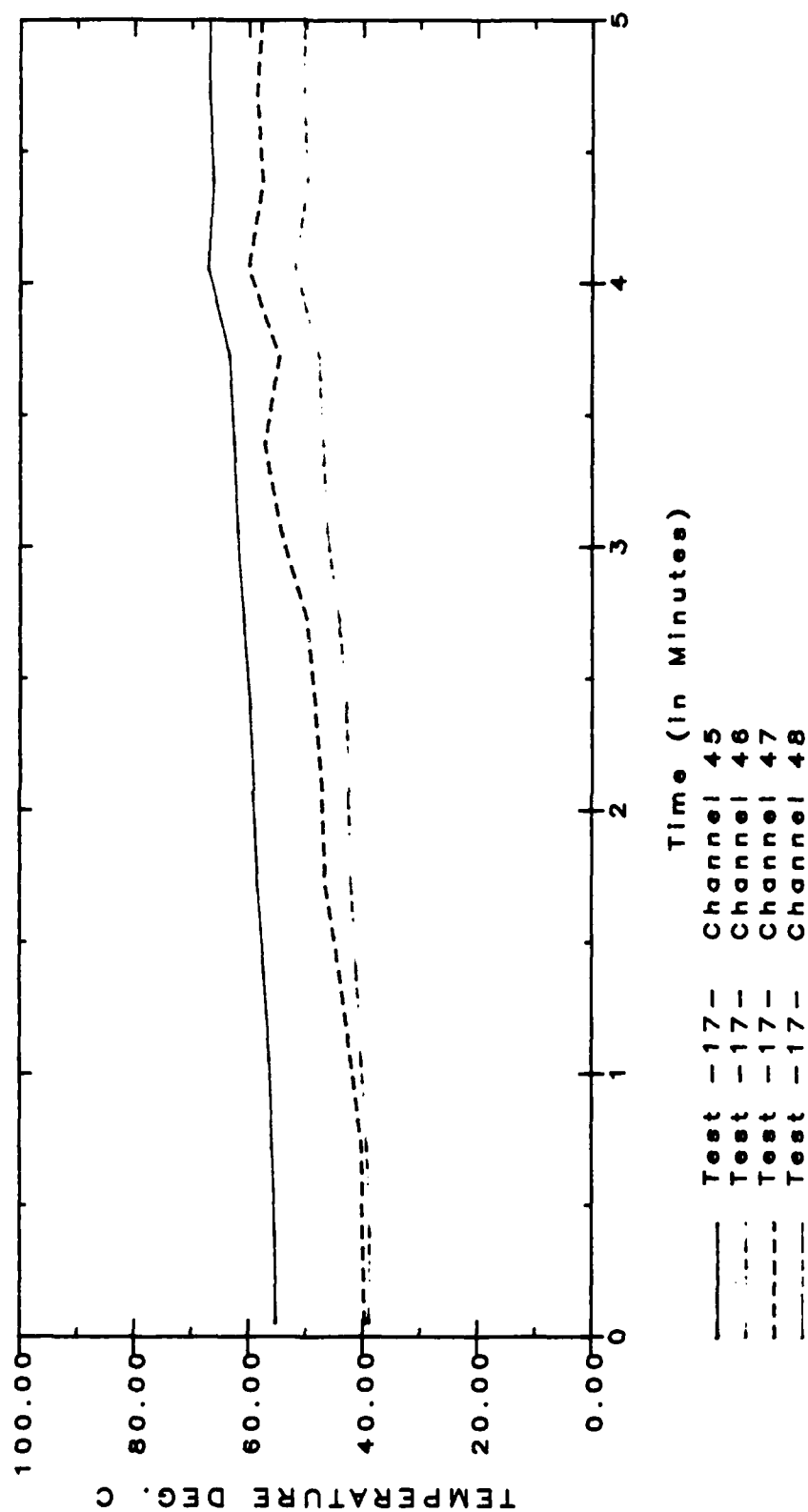
00:03:40 FAILURE
00:06:14 EXTINGUISHMENT

TANK TESTS



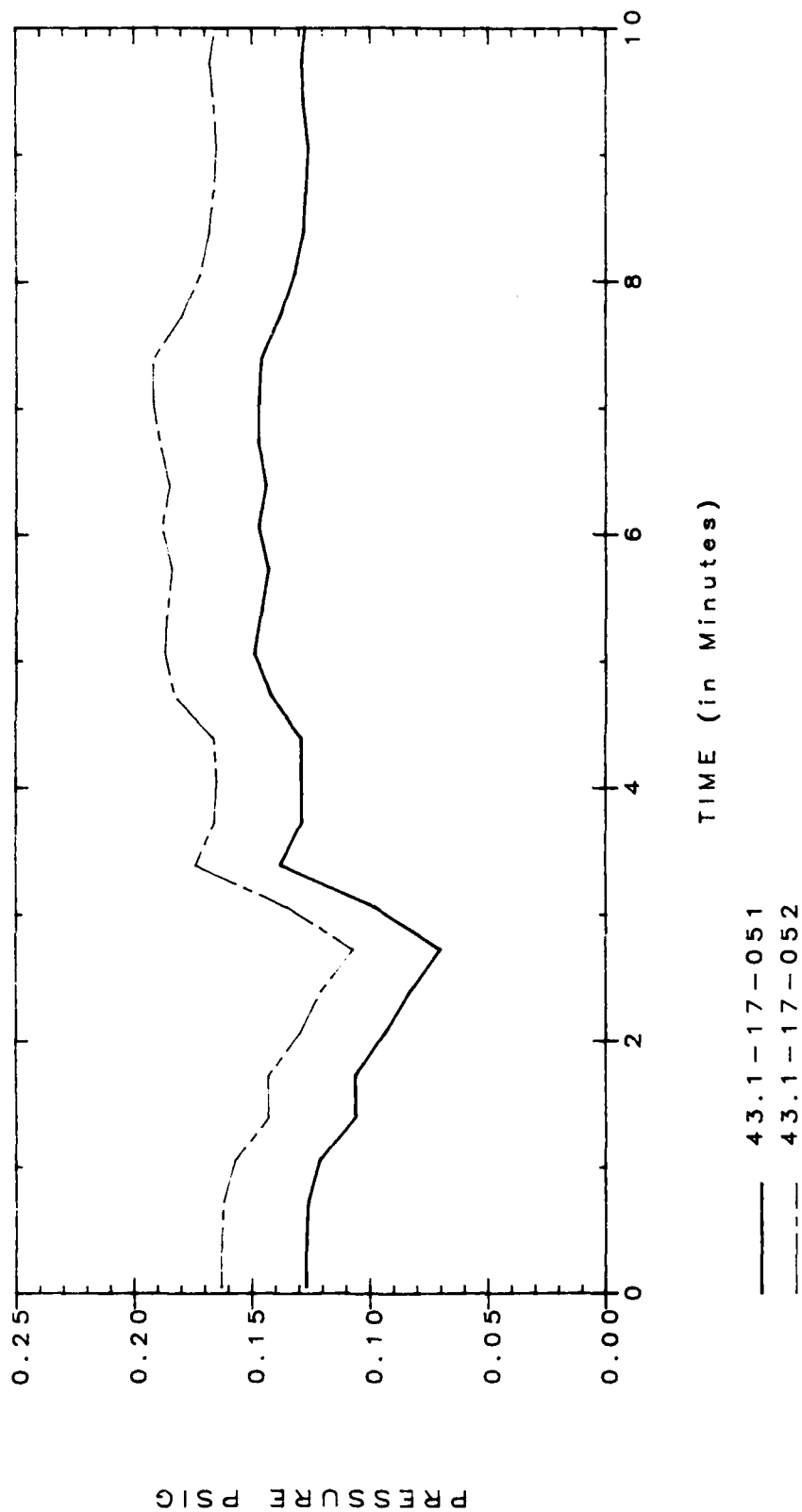
TIME/TEMPERATURE DATA

TANK TESTS



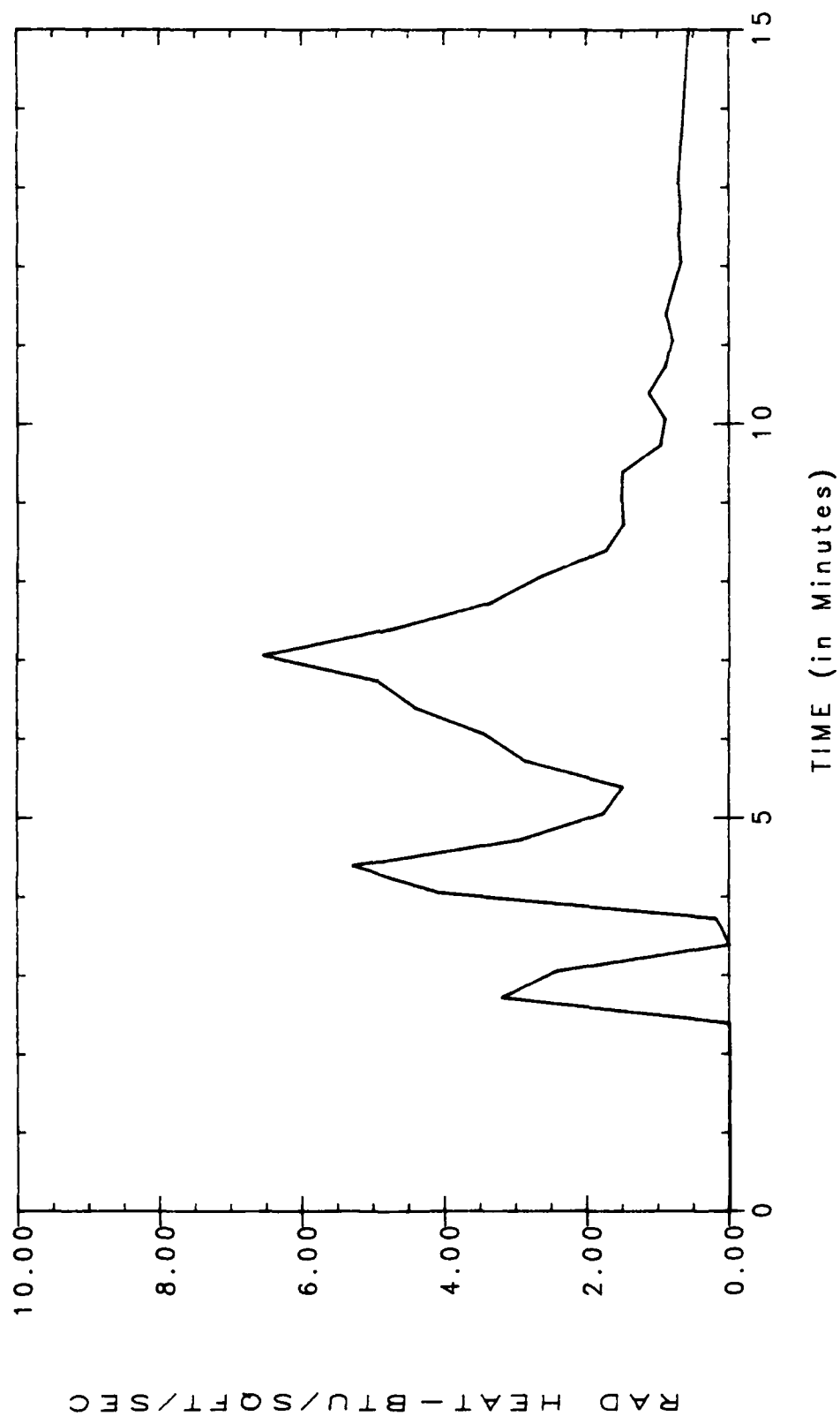
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

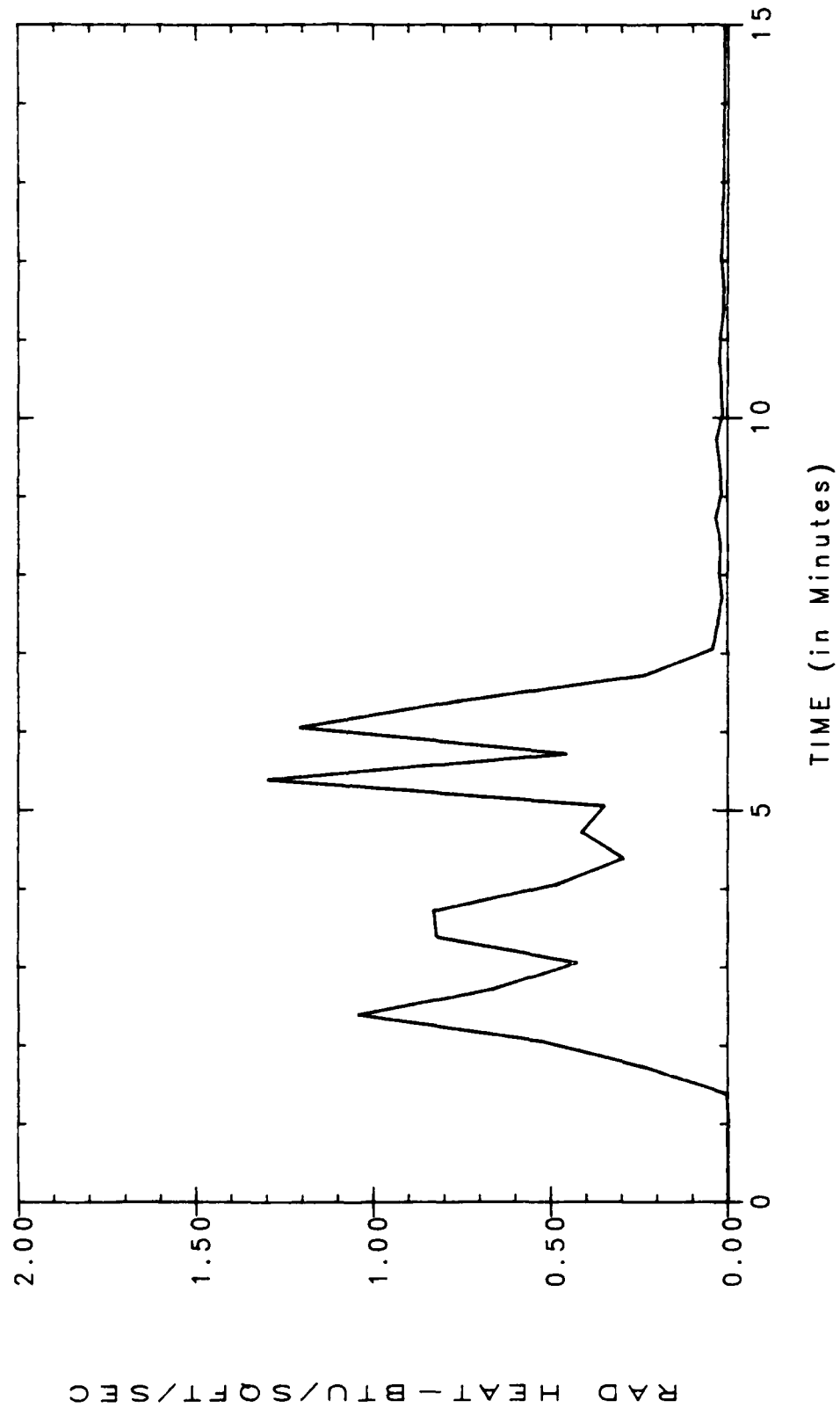
TANK TESTS



43.1-17-073.MD

HEAT FLUX DATA
RADIANT HEAT

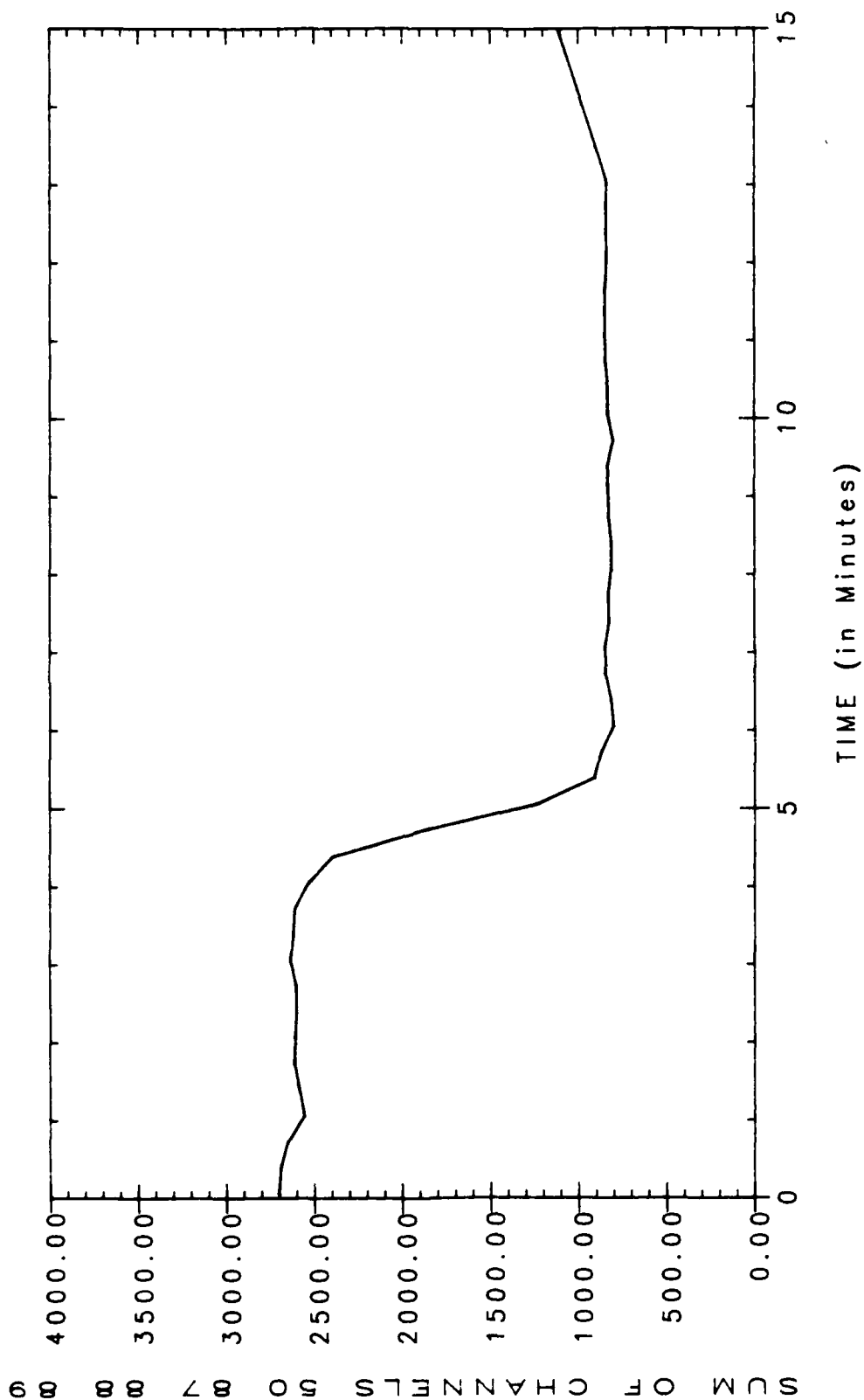
TANK TESTS



43.1-17-053.MD

HEAT FLUX DATA
RADIANT HEAT

TANK TESTS



43.1-17-086

WEIGHT LOSS DATA
TEST TANK

TEST # 19

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 100 SQ. FT.
DATE OF TEST: 26 JUNE 1986

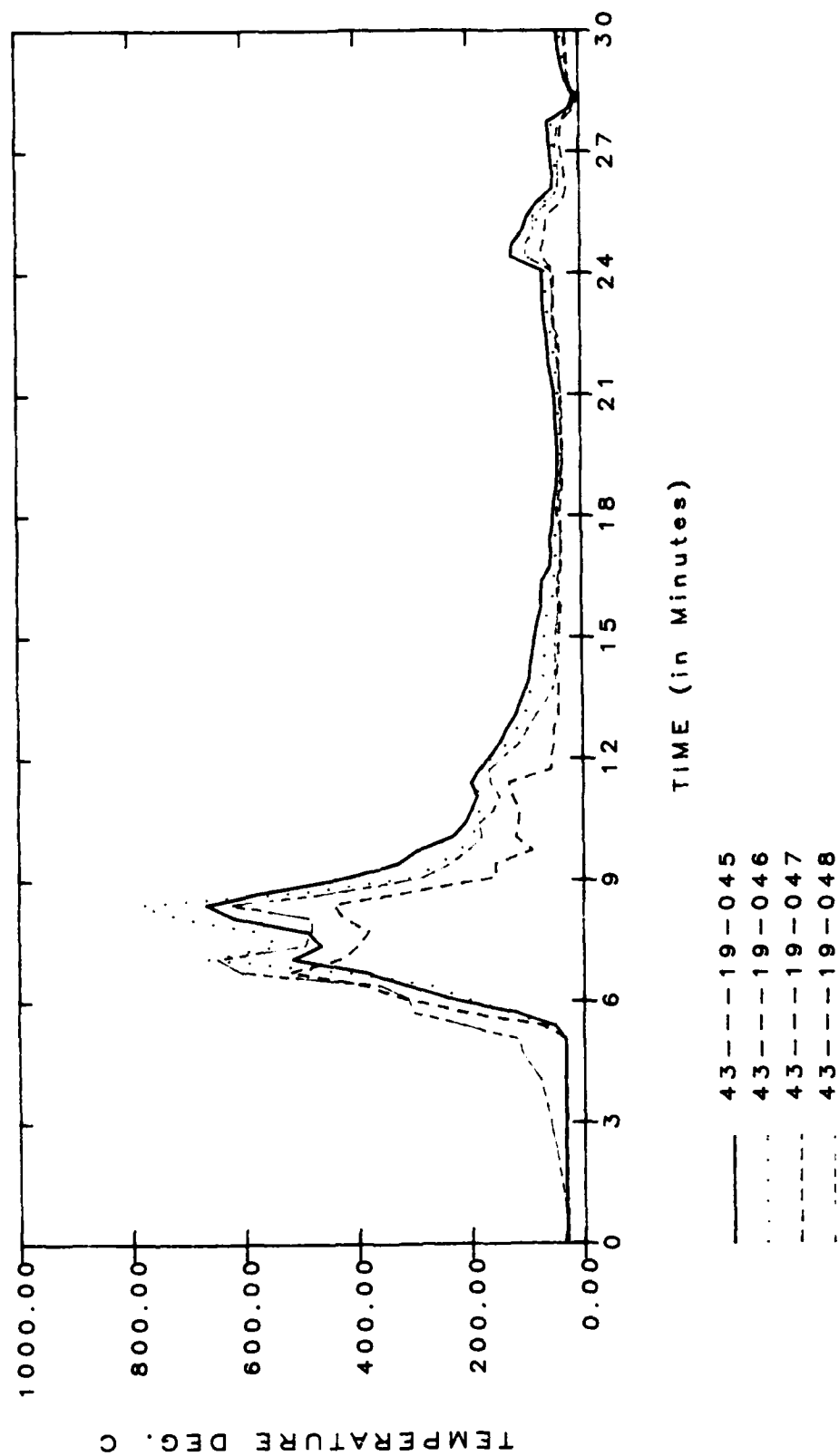
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

IMPOSSIBLE TO TELL WHEN FAILURE OCCURRED
00:04:50 AFFF APPLICATION
CONTROL TIME 1 MINUTE (SEE FROM TAPE)
00:22:35 REKINDLE
00:25:26 FIRST CO2 APPLICATION
00:27:30 FIRE OUT
00:27:50 SECOND CO2 APPLICATION

CAMERA LOCATION: 03 DECK

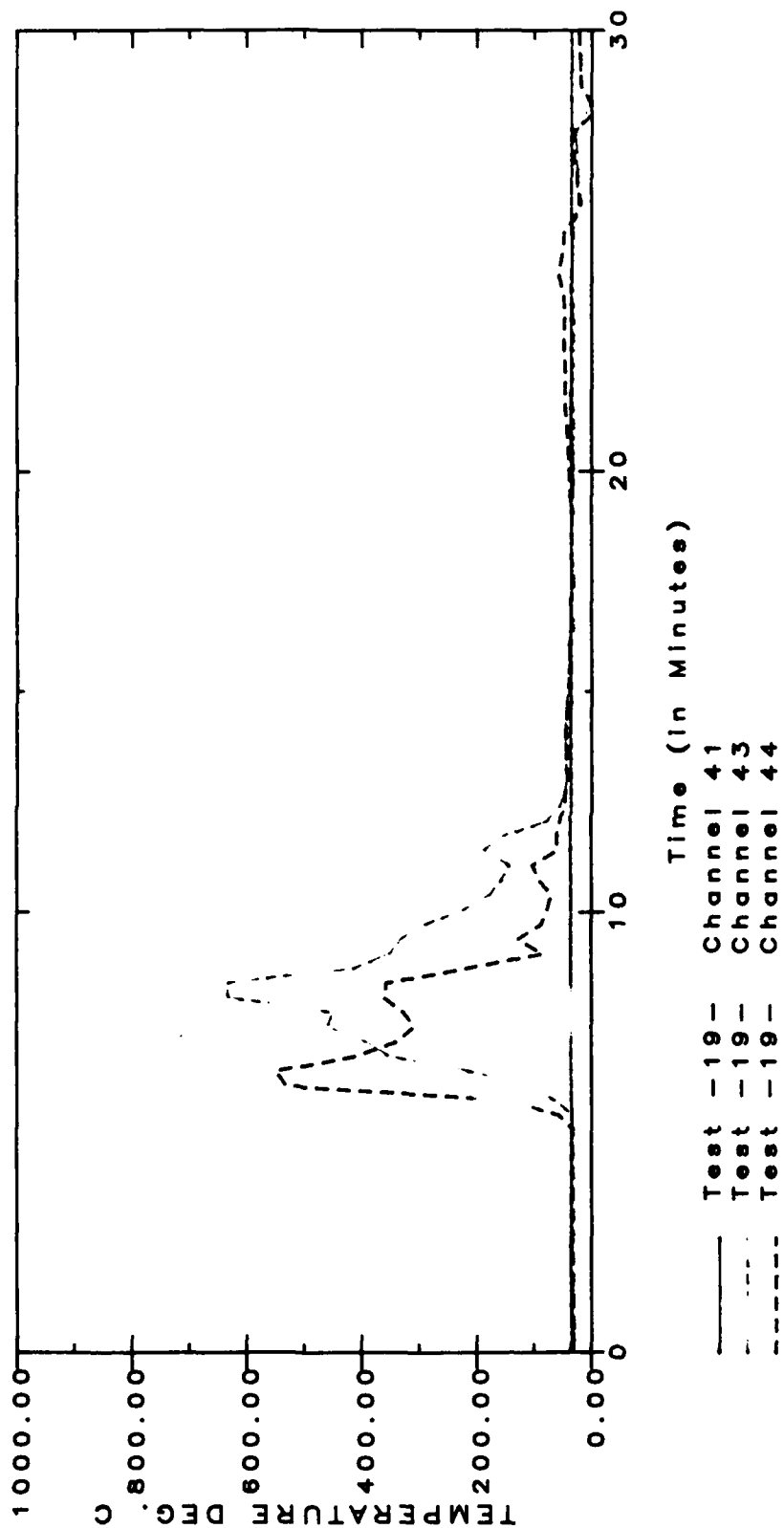
IMPOSSIBLE TO DISCERN TANK FAILURE
00:05:06 AFFF APPLICATION (CONTROL TIME 1 MINUTE 22 SECOND PER
TAPE)
00:22:35 REKINDLE
00:27:41 CO2 APPLICATION (CONTROL TIME 21 MINUTES PER TAPE)

TANK TESTS



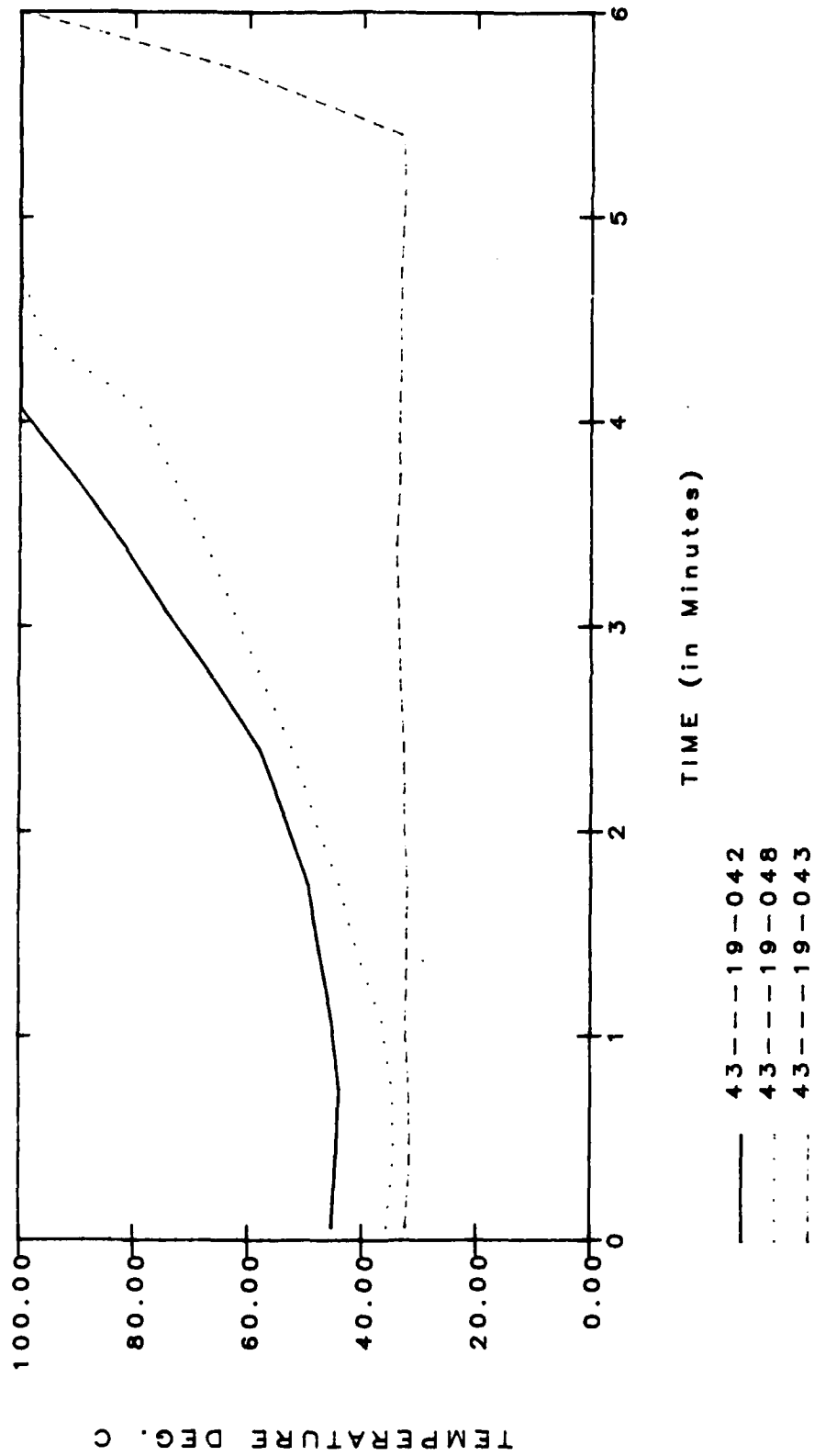
TIME/TEMPERATURE DATA

TANK TESTS



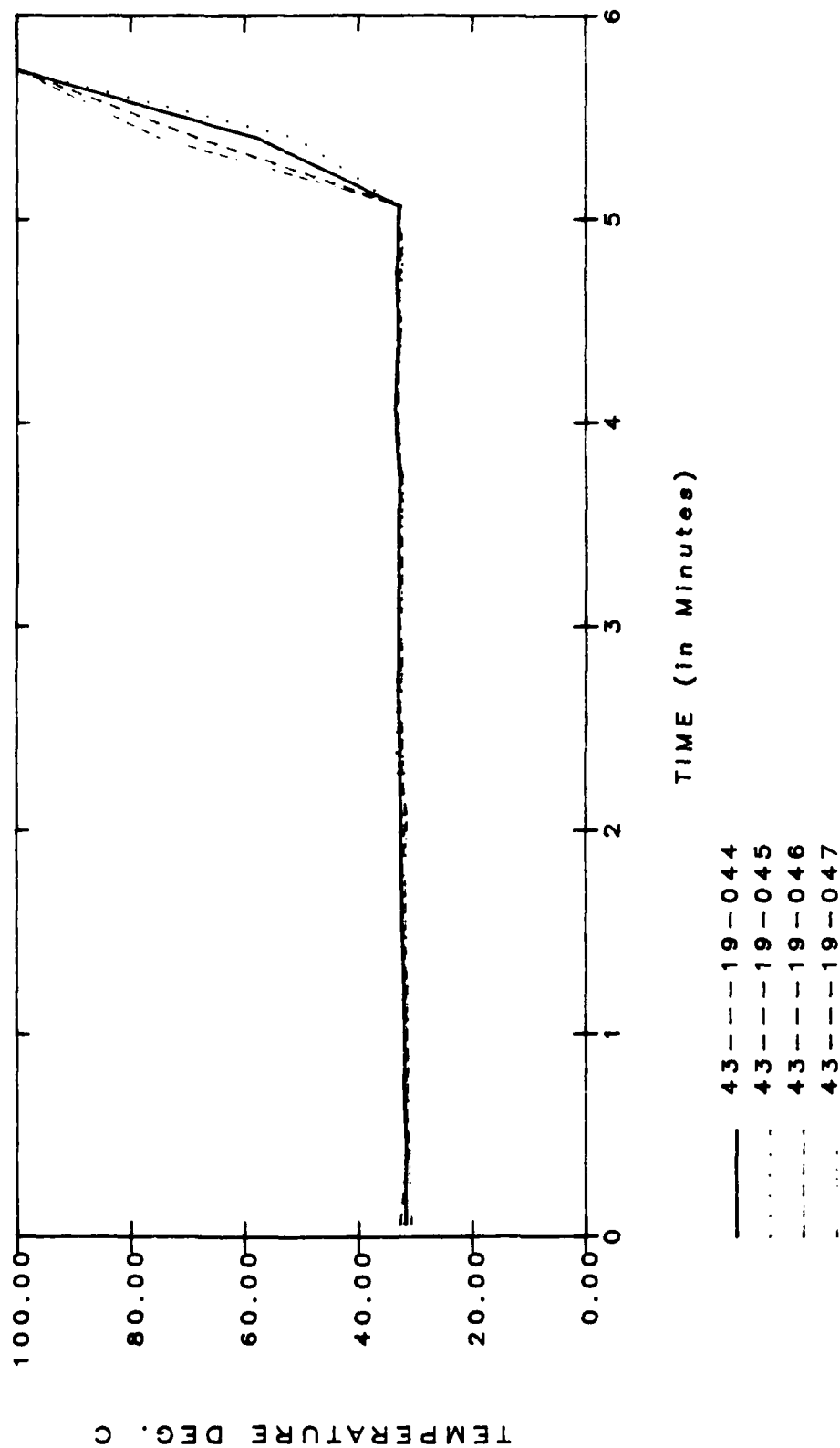
TIME/TEMPERATURE DATA

TANK TESTS



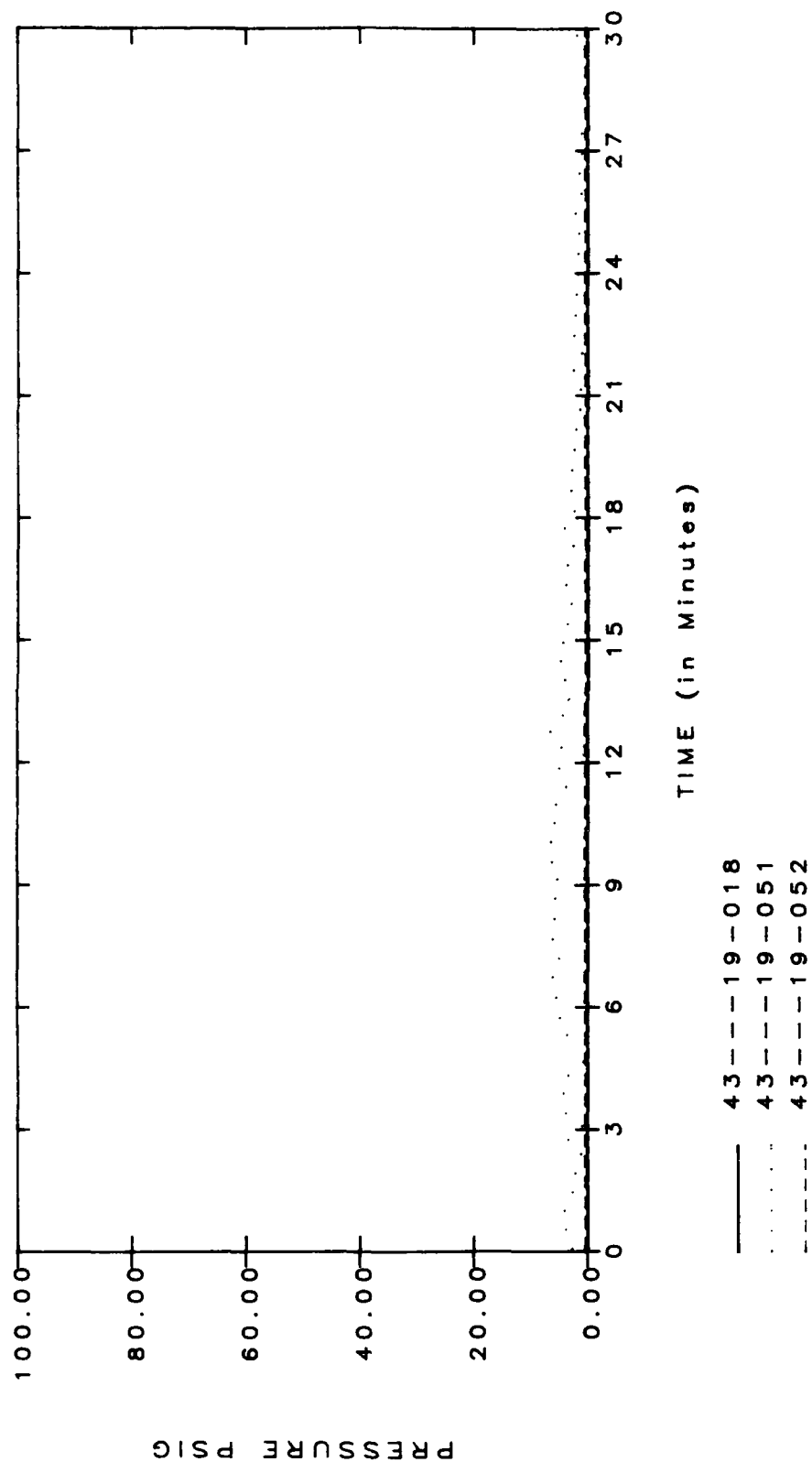
TIME/TEMPERATURE DATA

TANK TESTS



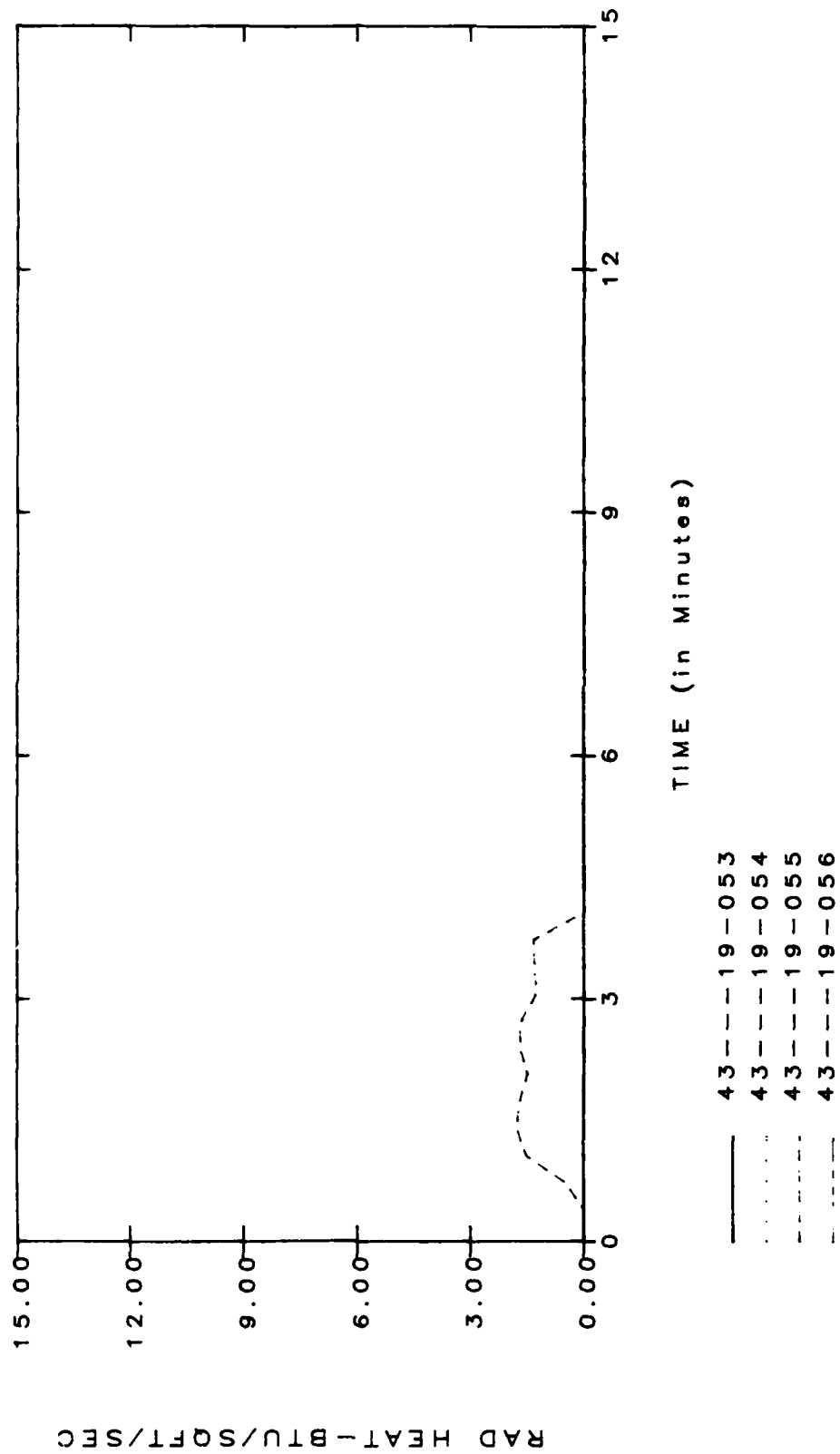
TIME/TEMPERATURE DATA

TANK TESTS

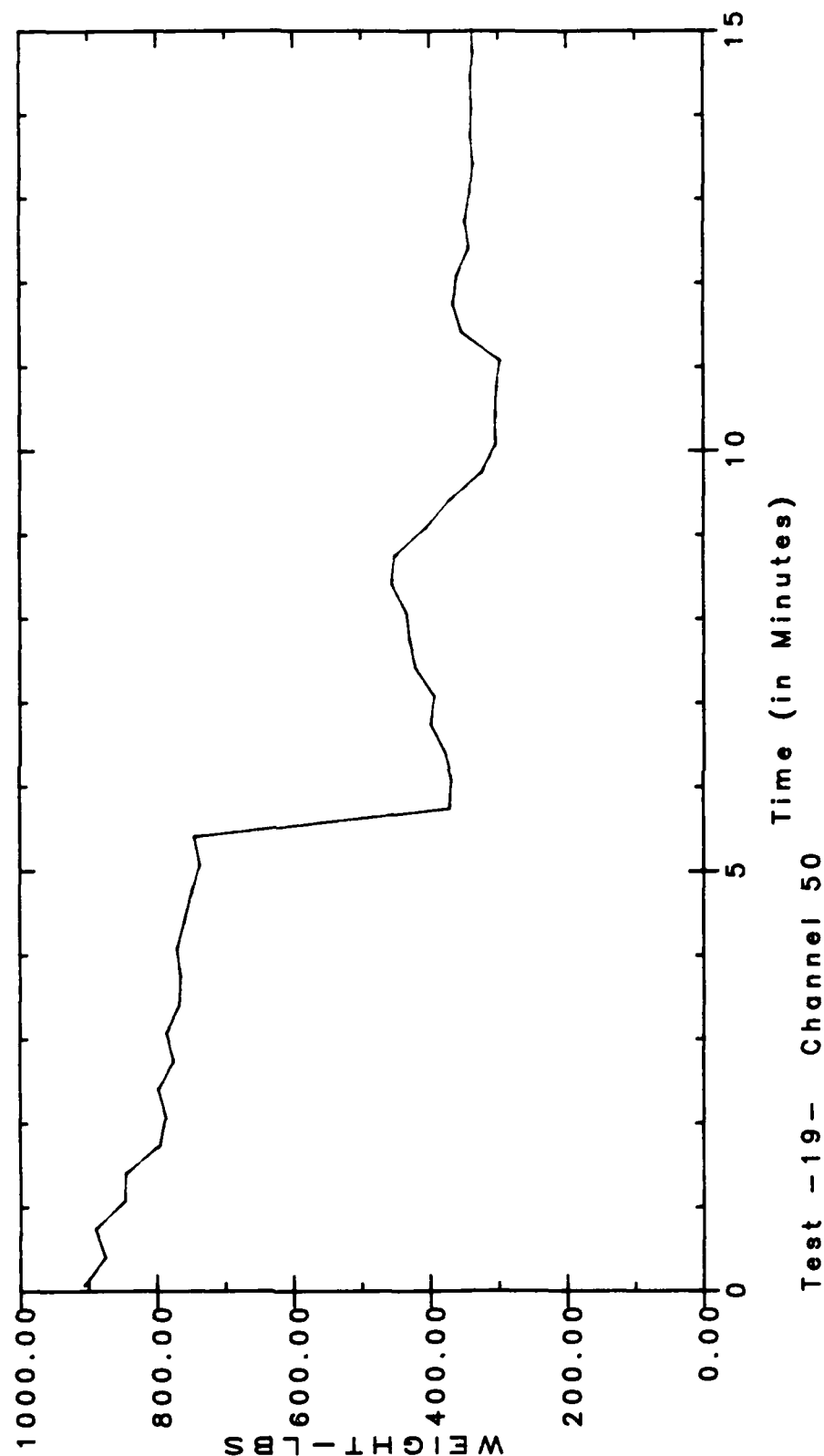


IN-TANK PRESSURE DATA

TANK TESTS

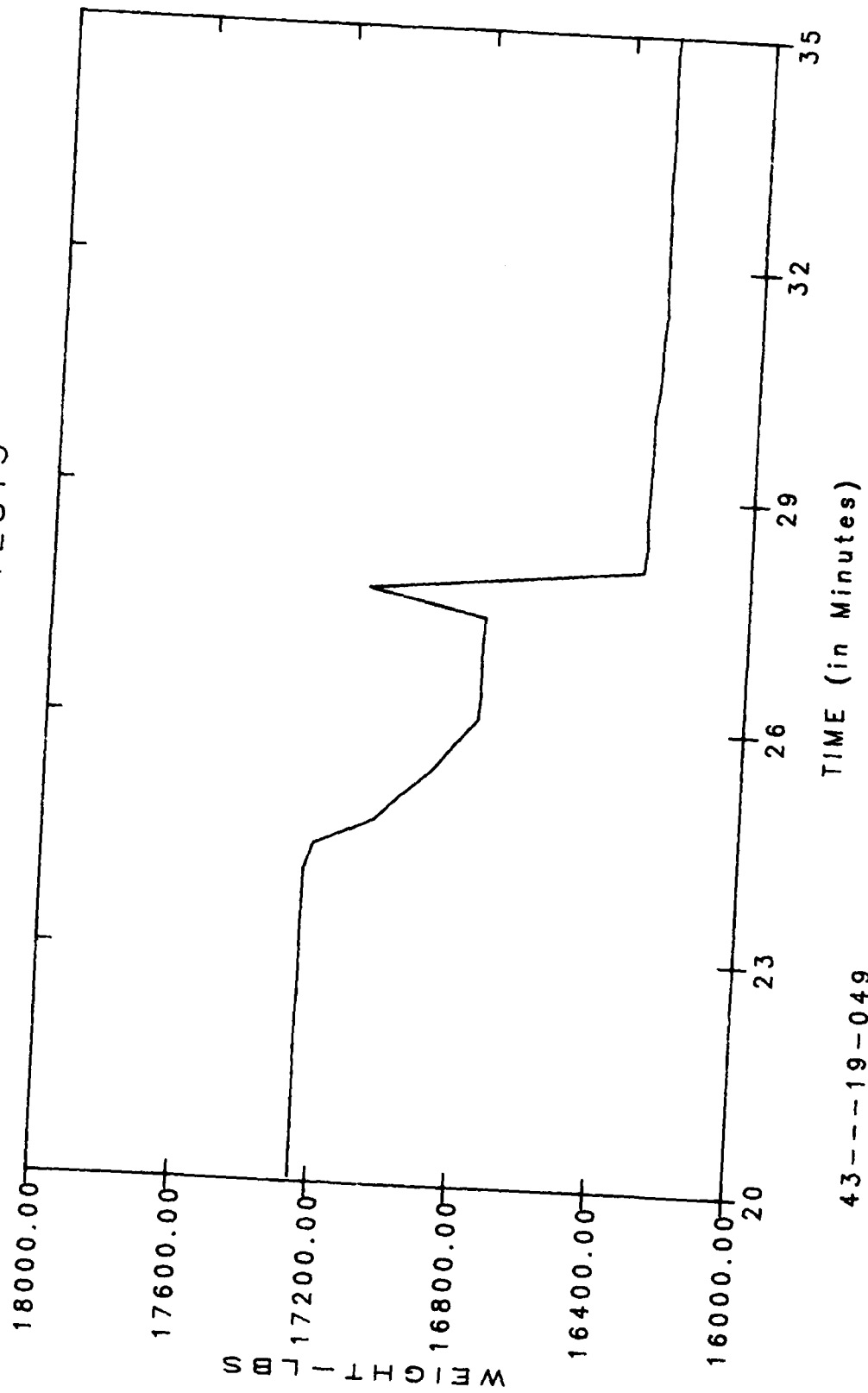


TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TANK TESTS



WEIGHT LOSS DATA
CARDOX TANK

TEST # 22

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 1 JULY 1986

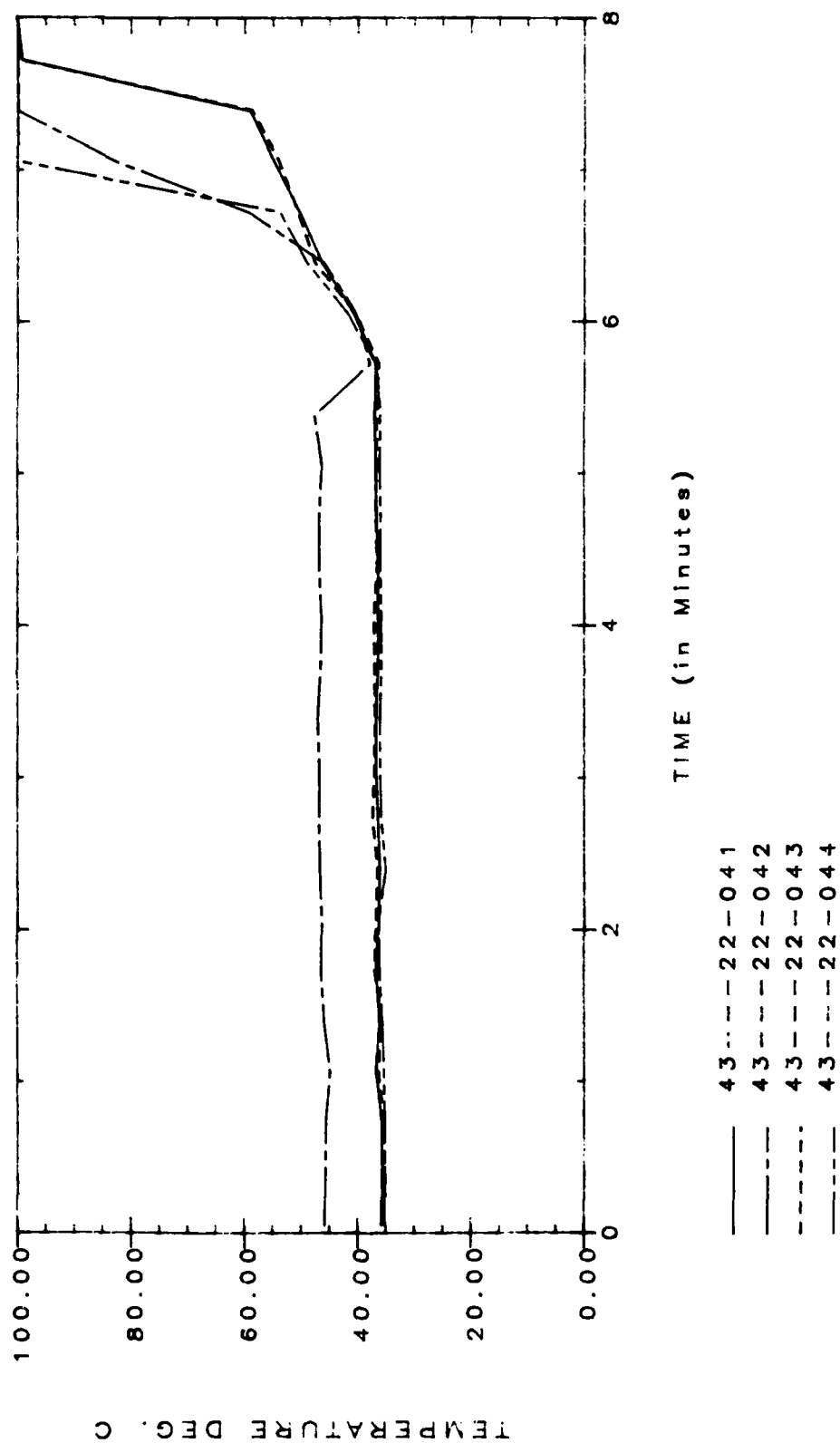
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:18 TANK FAILED
00:39:30 CO2 APPLICATION, FIRE NOT EXTINGUISHED
00:50:37 PURPLE K APPLICATION, FIRE NOT EXTINGUISHED
00:56:53 H2O FOG APPLICATION
00:58:30 EXTINGUISHMENT

CAMERA LOCATION: 03 DECK

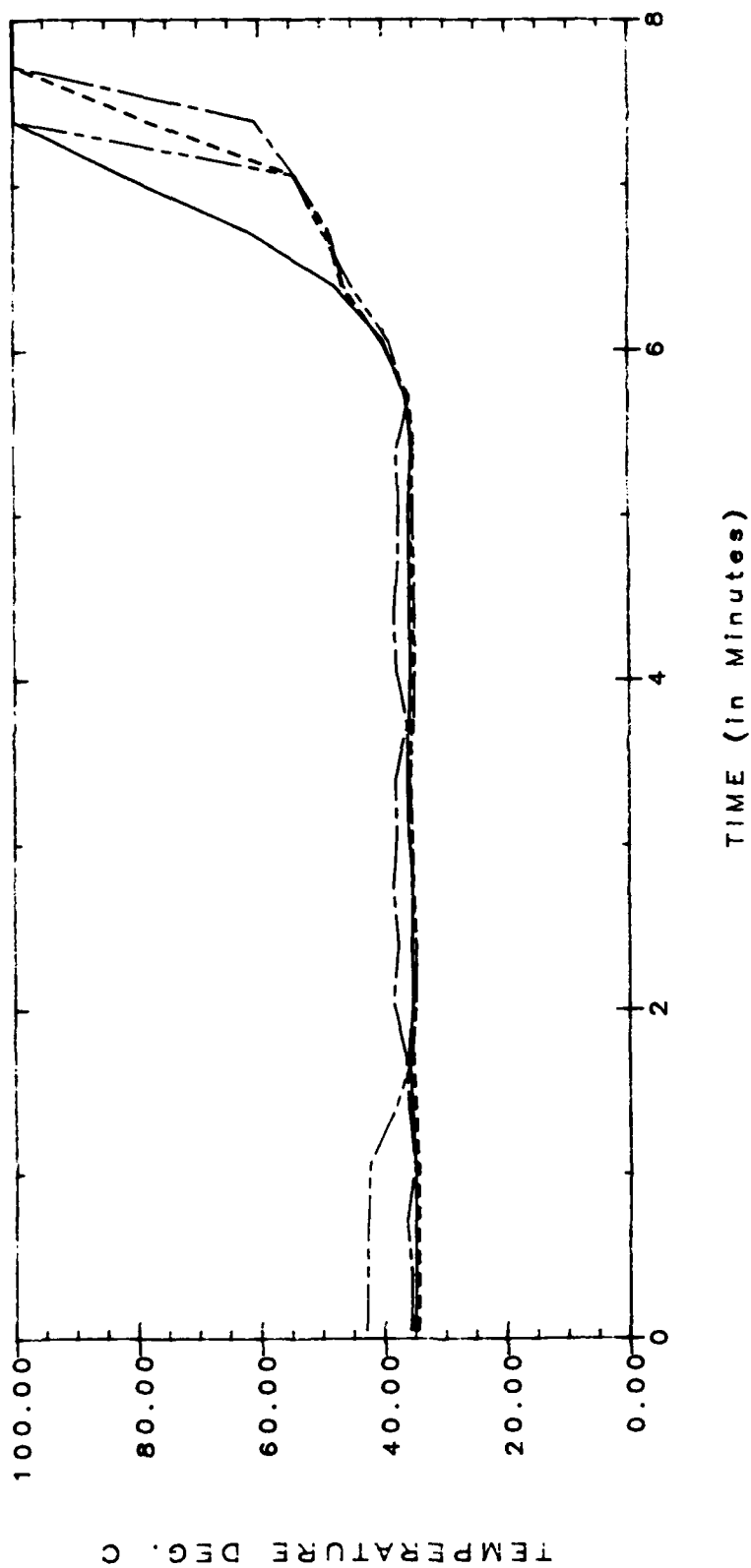
00:05:18 FAILURE
00:39:30 CO2 APPLICATION, FIRE UNDER CONTROL, NOT EXTINGUISHED
00:49:15 CO2 EXTINGUISHMENT (F&STD PERSONNEL)
00:50:35 PURPLE K APPLICATION, FIRE NOT CONTROLLED
00:56:52 H2O FOG APPLICATION
00:58:30 FIRE OUT

TANK TESTS



TIME/TEMPERATURE DATA

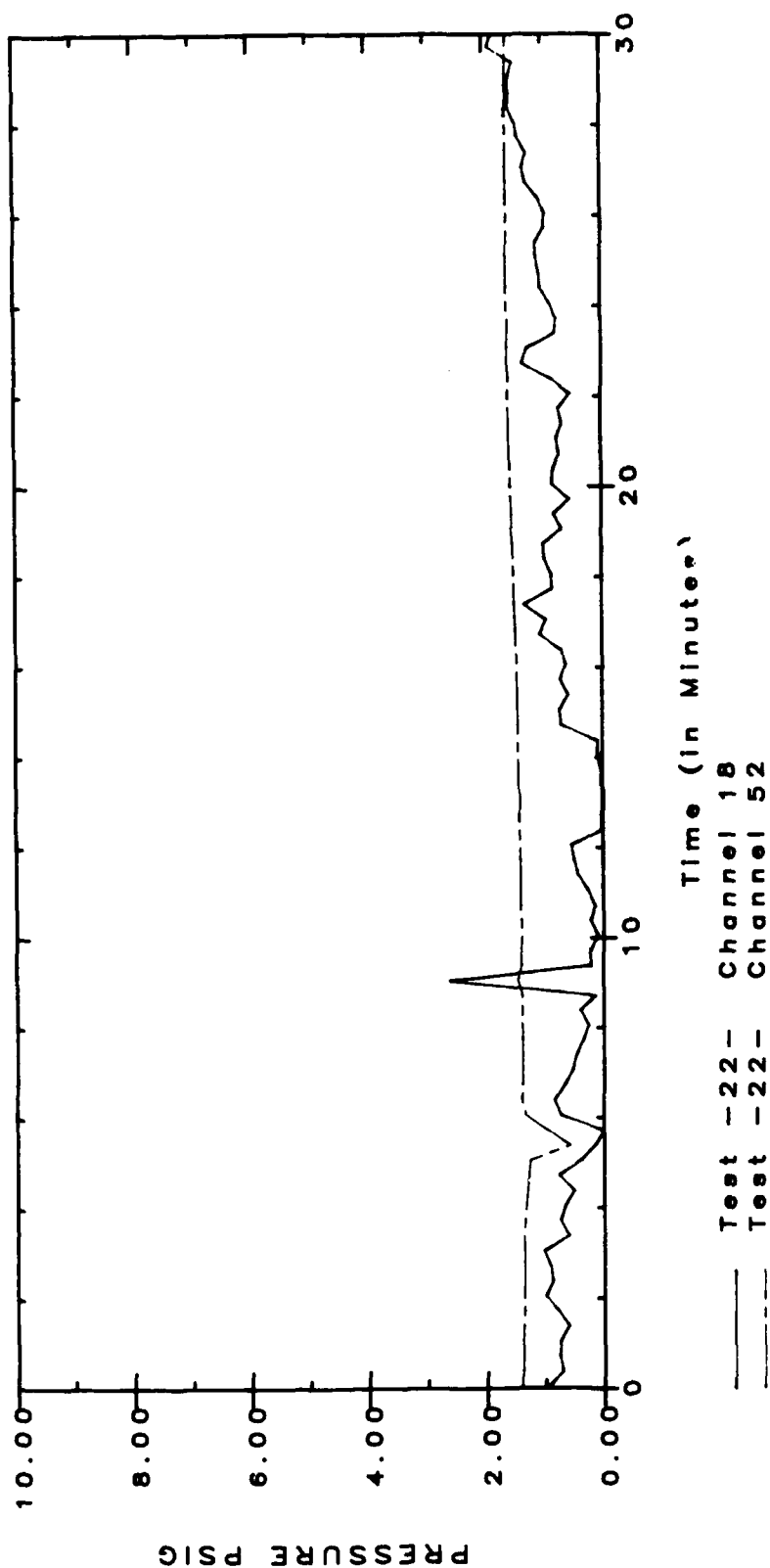
TANK TESTS



43-22-045
 43-22-046
 43-22-047
 43-22-048

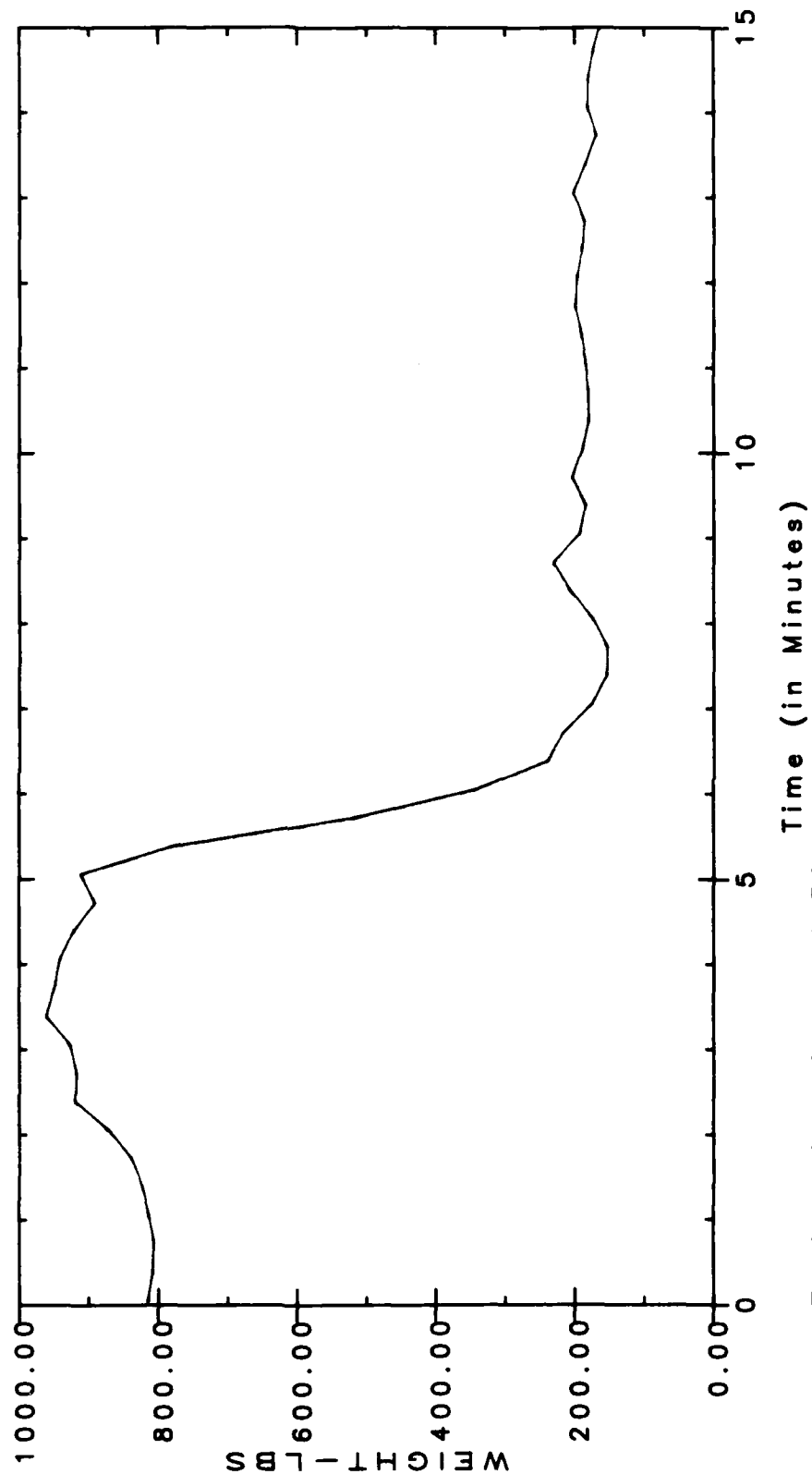
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

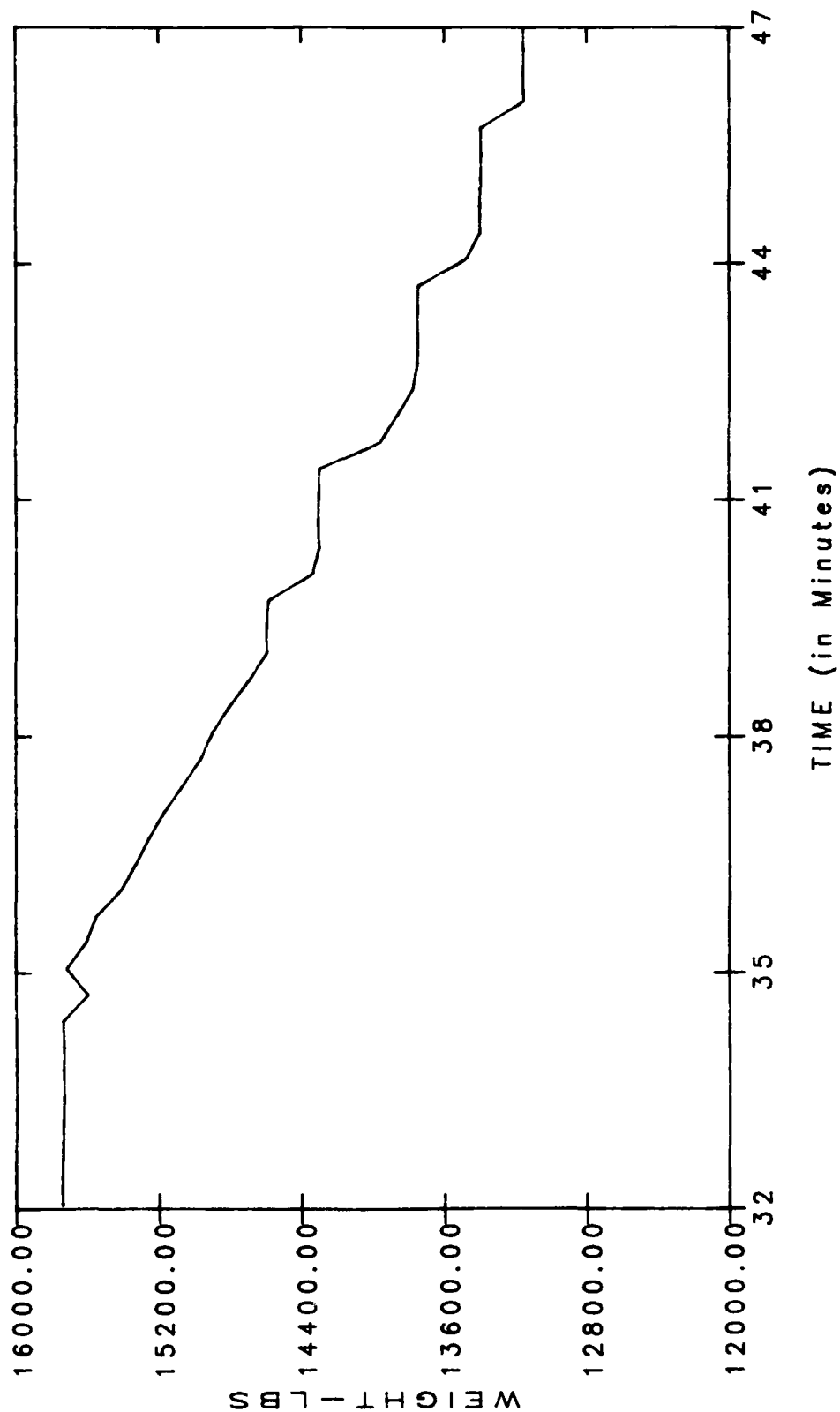
TANK TESTS



Test -22- Channel 50

WEIGHT LOSS DATA
TEST TANK

TANK TESTS



43---22-049

WEIGHT LOSS DATA
CARDOX TANK

TEST # 23

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH 150 GALLONS
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 15 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:49 TANK APPEARS TO HAVE RUPTURED
00:12:05 EXTINGUISHMENT

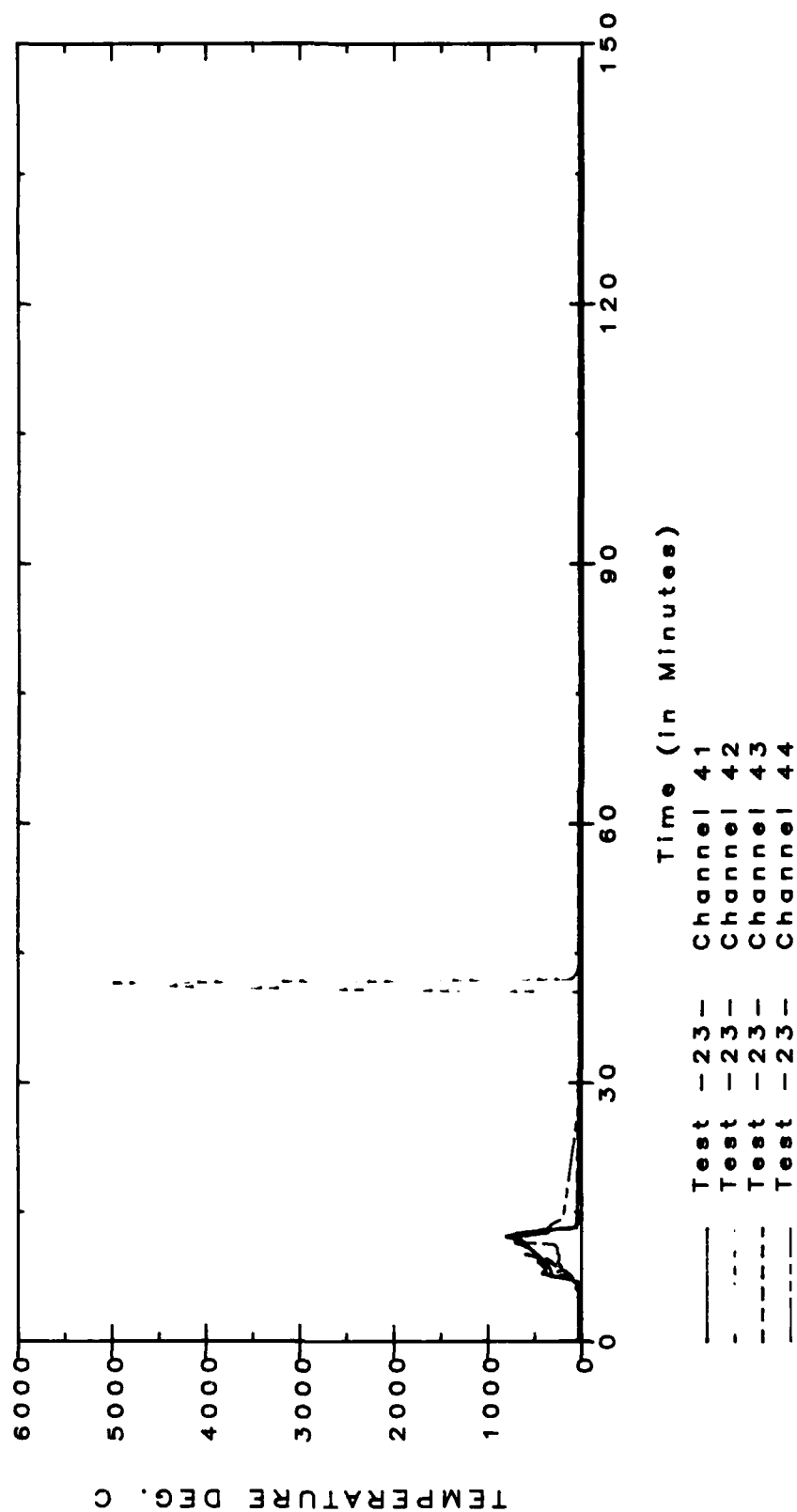
CAMERA LOCATION: 03 DECK

00:04:49 TANK RUPTURES
00:09:31 TOP APPEARS CHARRED
00:21:01 FIRE IN TANK
00:12:05 EXTINGUISHMENT

CAMERA LOCATION: 04 DECK

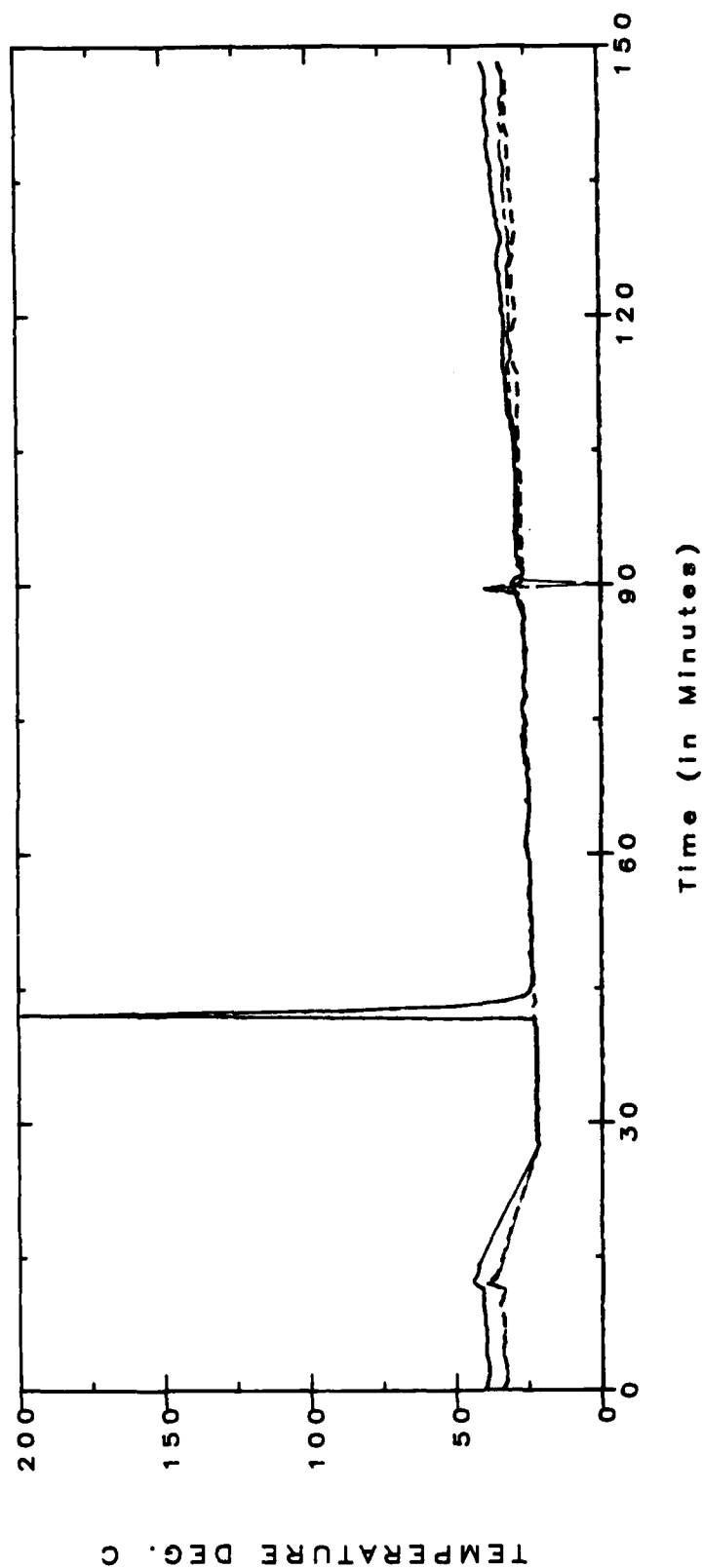
00:04:48 TANK FAILED (00:04:50 VOICE)
00:09:33 TANK TOP APPEARS TO HAVE FAILED
00:12:05 EXTINGUISHMENT

TANK TESTS



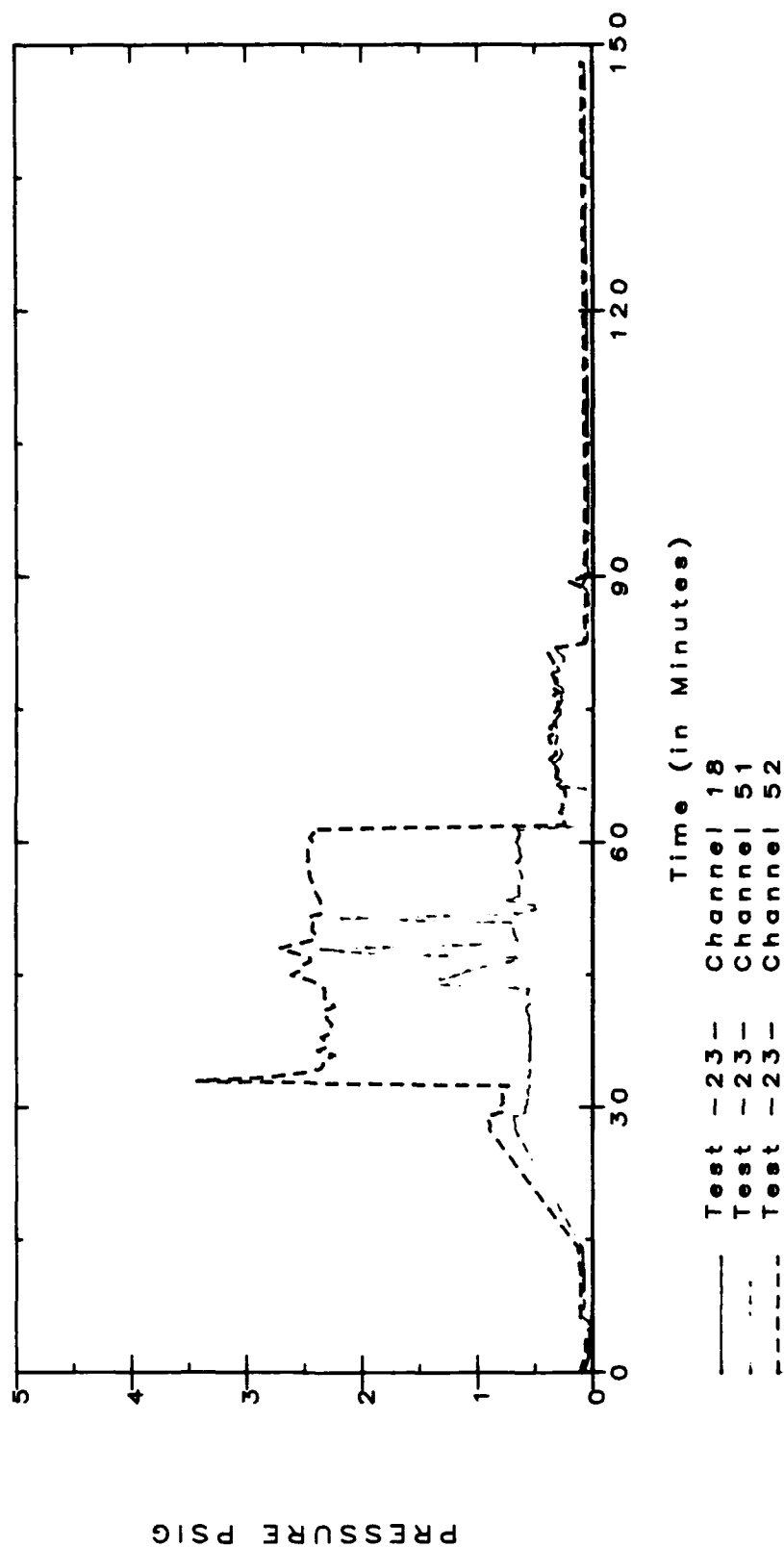
TIME/TEMPERATURE DATA

TANK TESTS



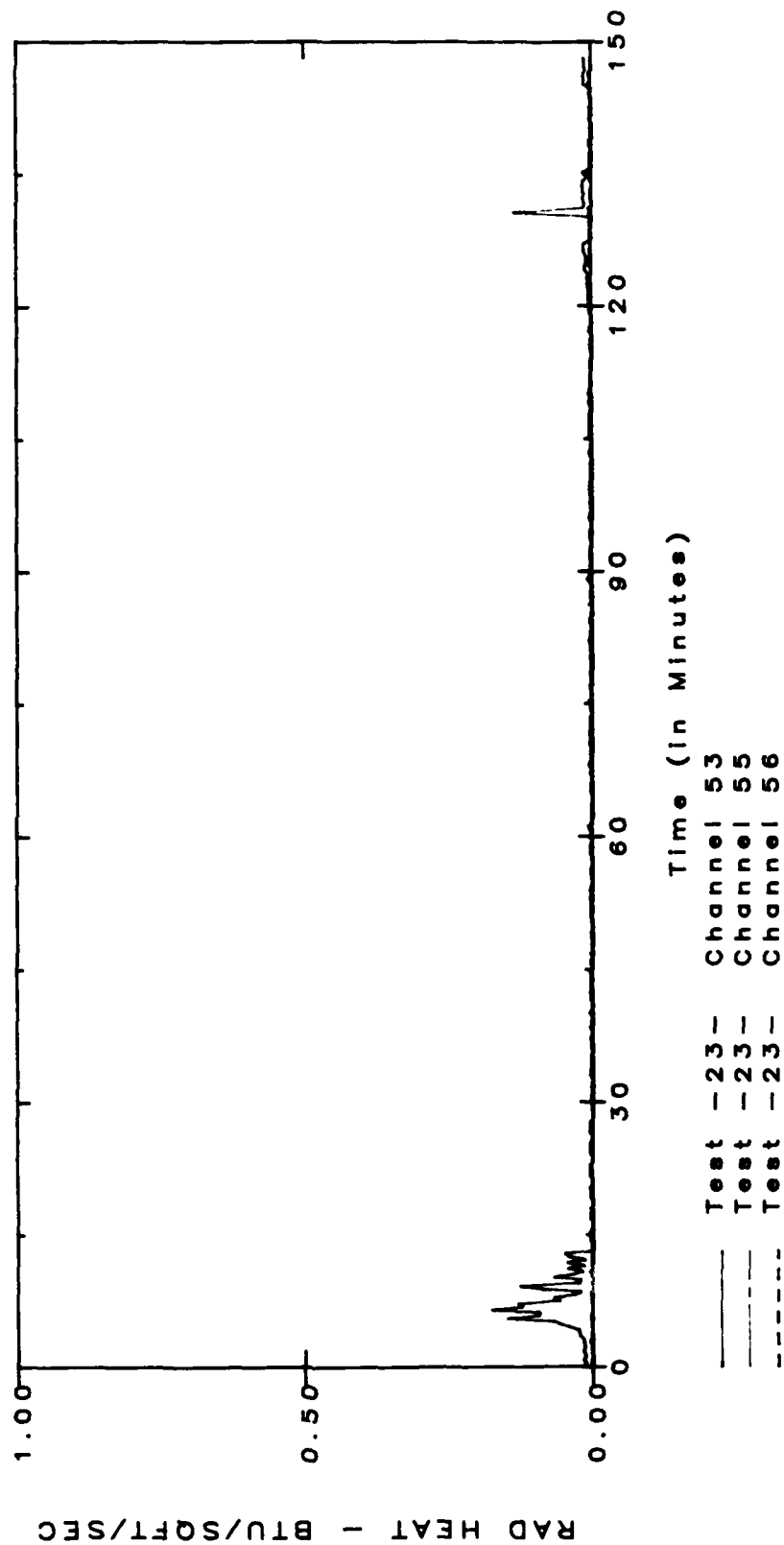
TIME/TEMPERATURE DATA

TANK TESTS



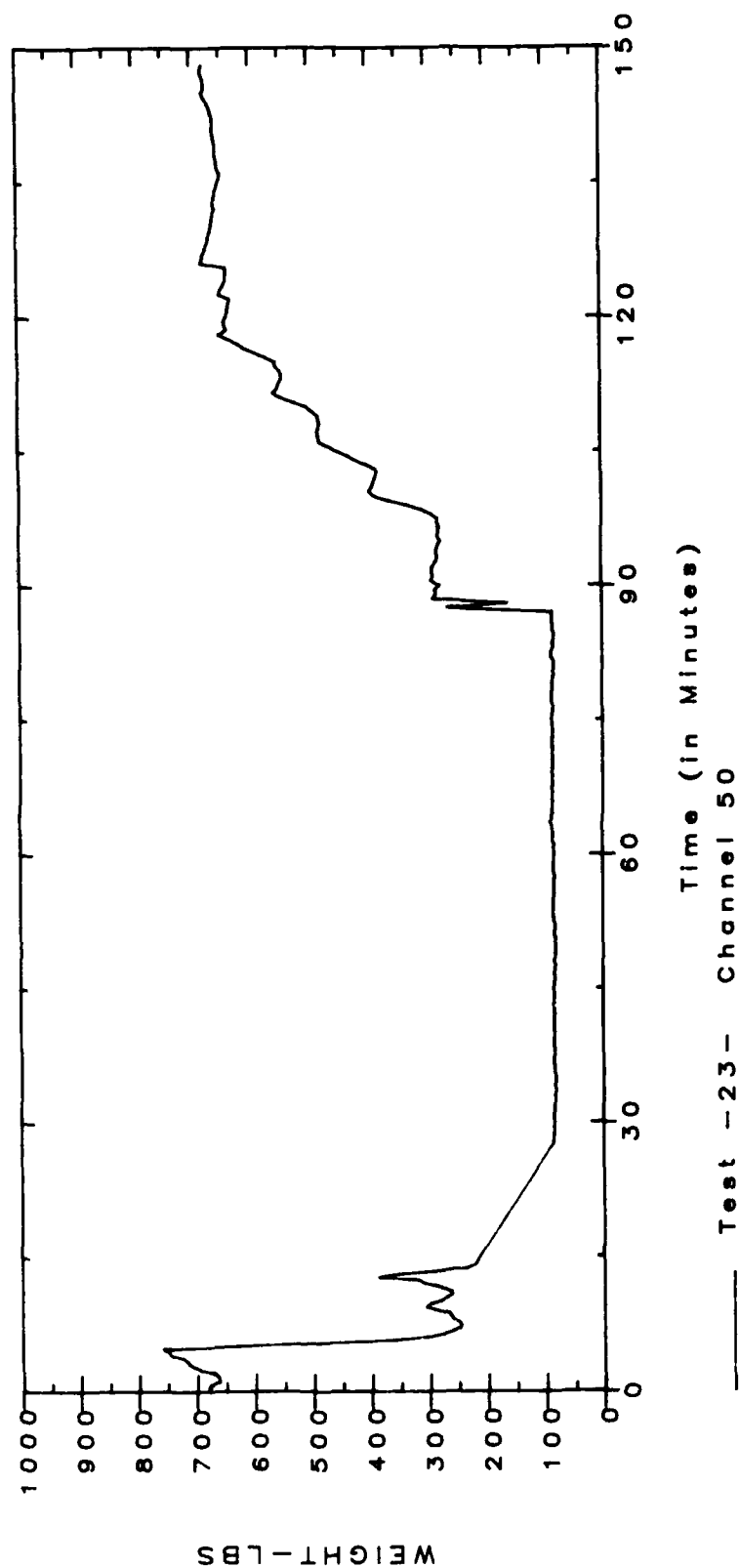
IN-TANK PRESSURE DATA

TANK TESTS



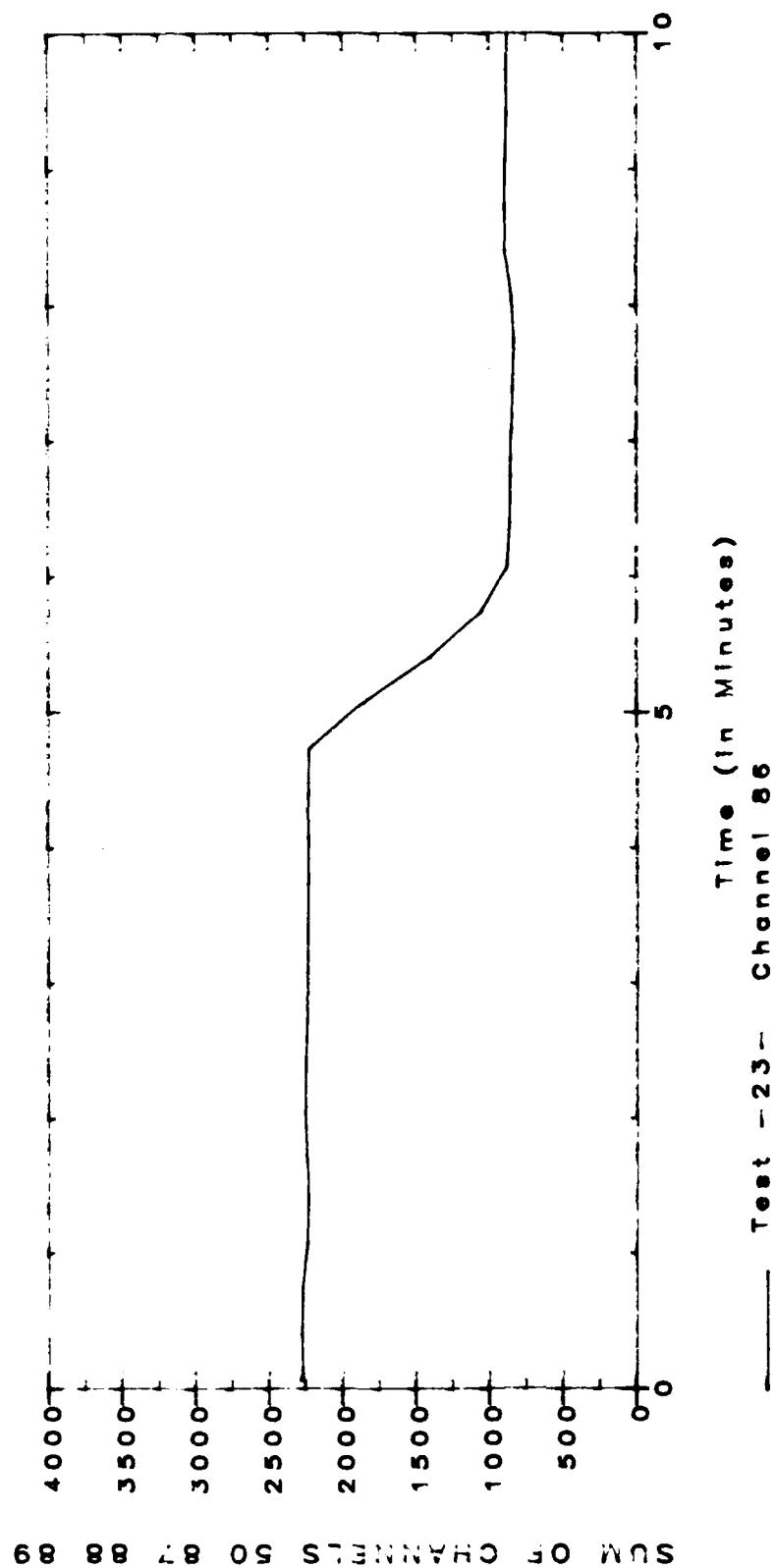
HEAT FLUX DATA RADIANT HEAT

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TEST # 25

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 2 JULY 1986

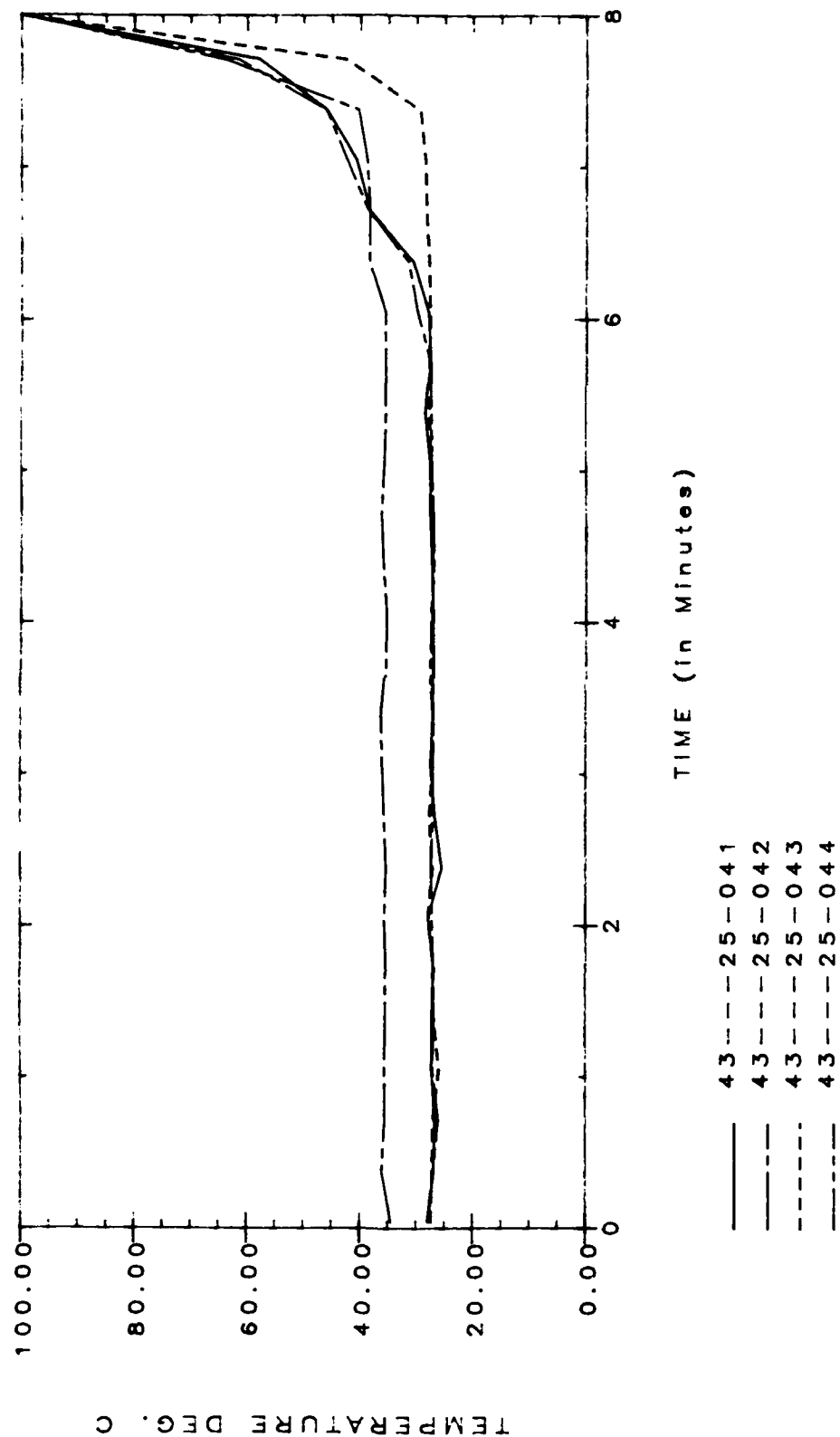
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:44 TANK FAILURE (BOTTOM)
00:08:00 TANK TOP ON FIRE
00:11:00 AFFF APPLICATION
00:11:45 FIRE CONTROLLED?
00:12:00 REKINDLE, EXTINGUISHMENT TIME 16 MINUTES

CAMERA LOCATION: 03 DECK

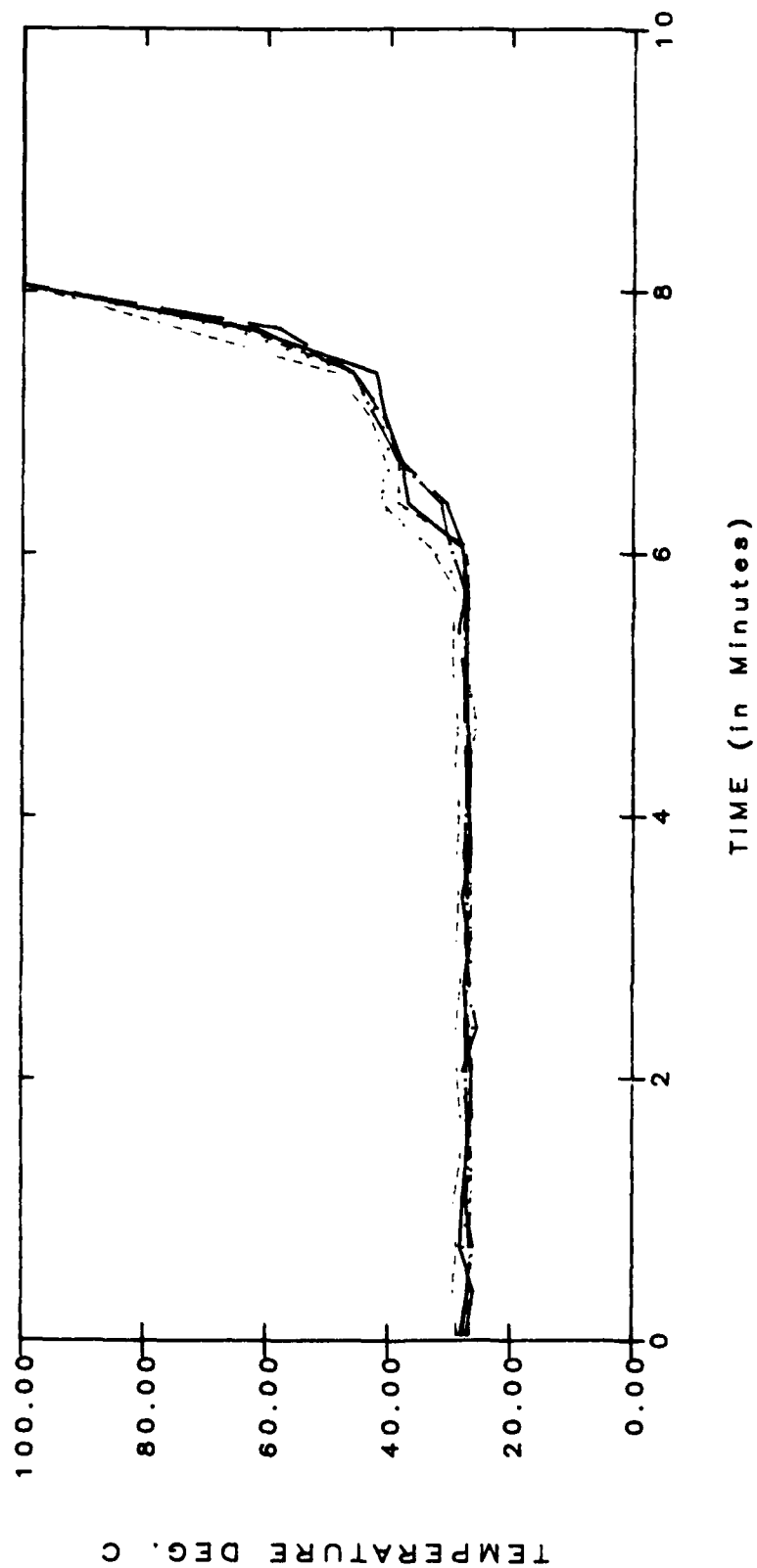
00:05:44 FAILURE
00:11:02 AFFF APPLICATION
00:11:52 REKINDLE

TANK TESTS



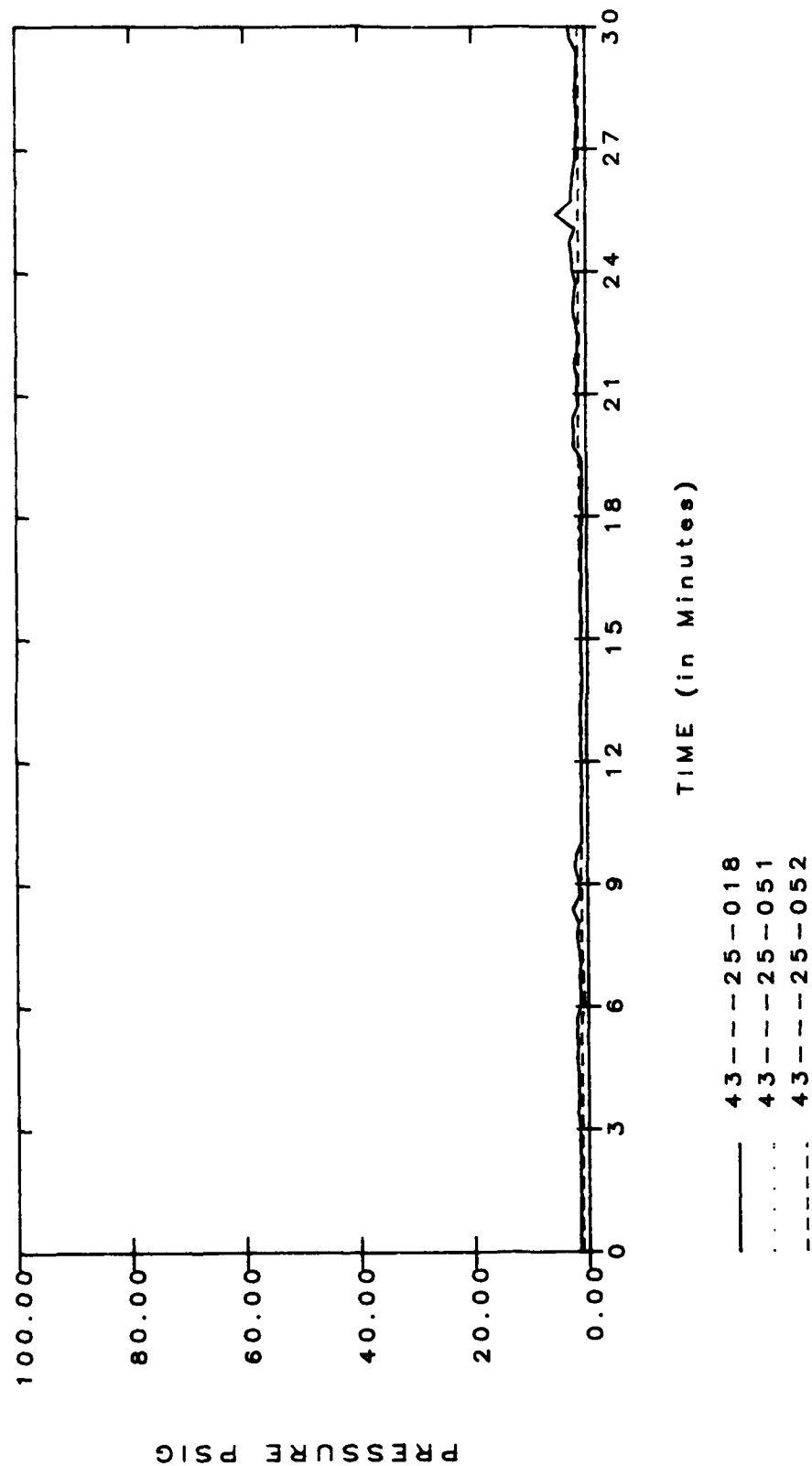
TIME/TEMPERATURE DATA

TANK TESTS



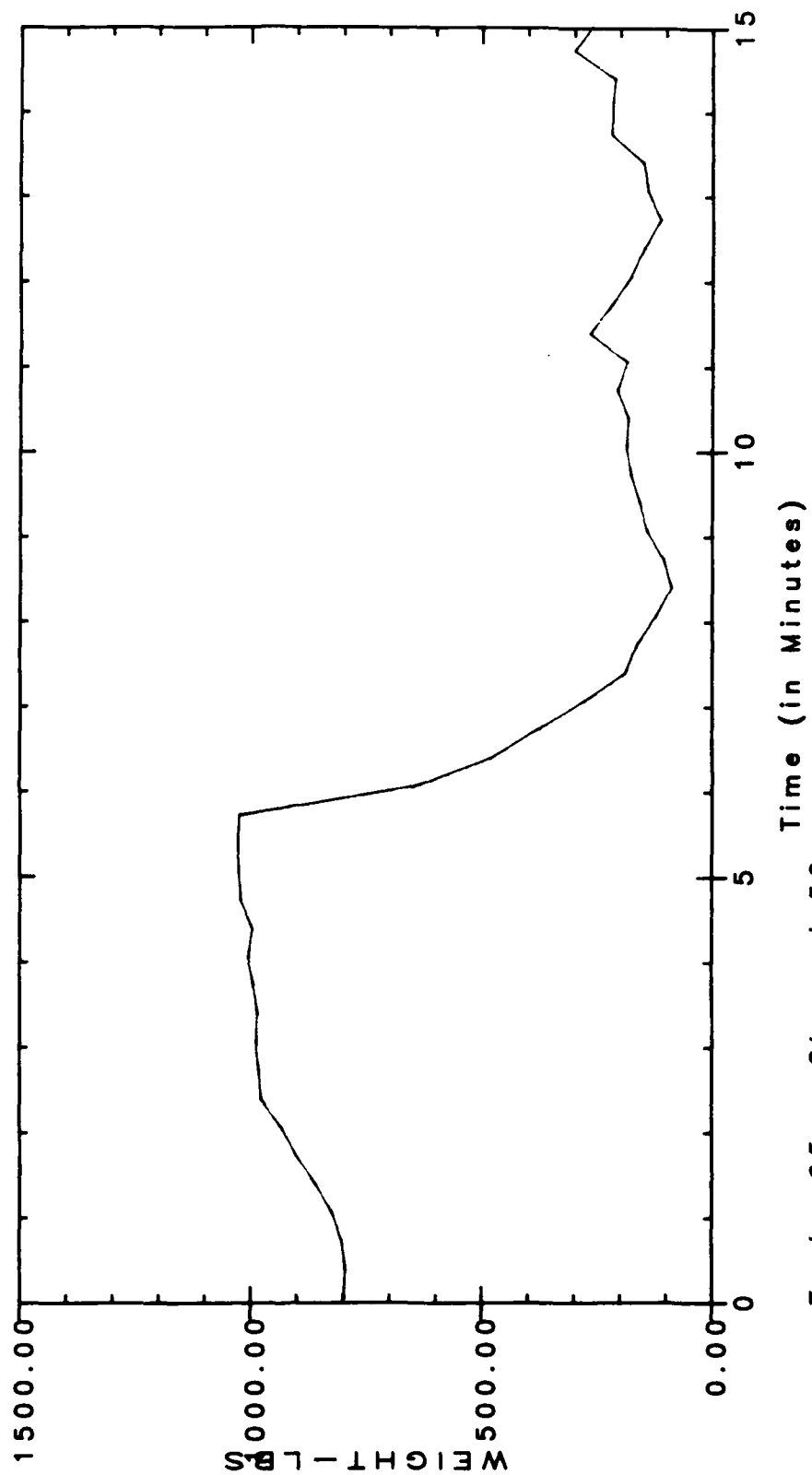
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TEST # 26

TYPE OF TANK: POLYETHYLENE TANK
TANK CONTENTS: ETOH 300 GALLON CENTER TANK, H2O 600 GALLON
OUTBOARD
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 13 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:05:12 CENTER TANK FAILED
00:11:00 TANKS OBSCURED BY FLAMES
00:18:00 OUTER TANK TOP COLLAPSED

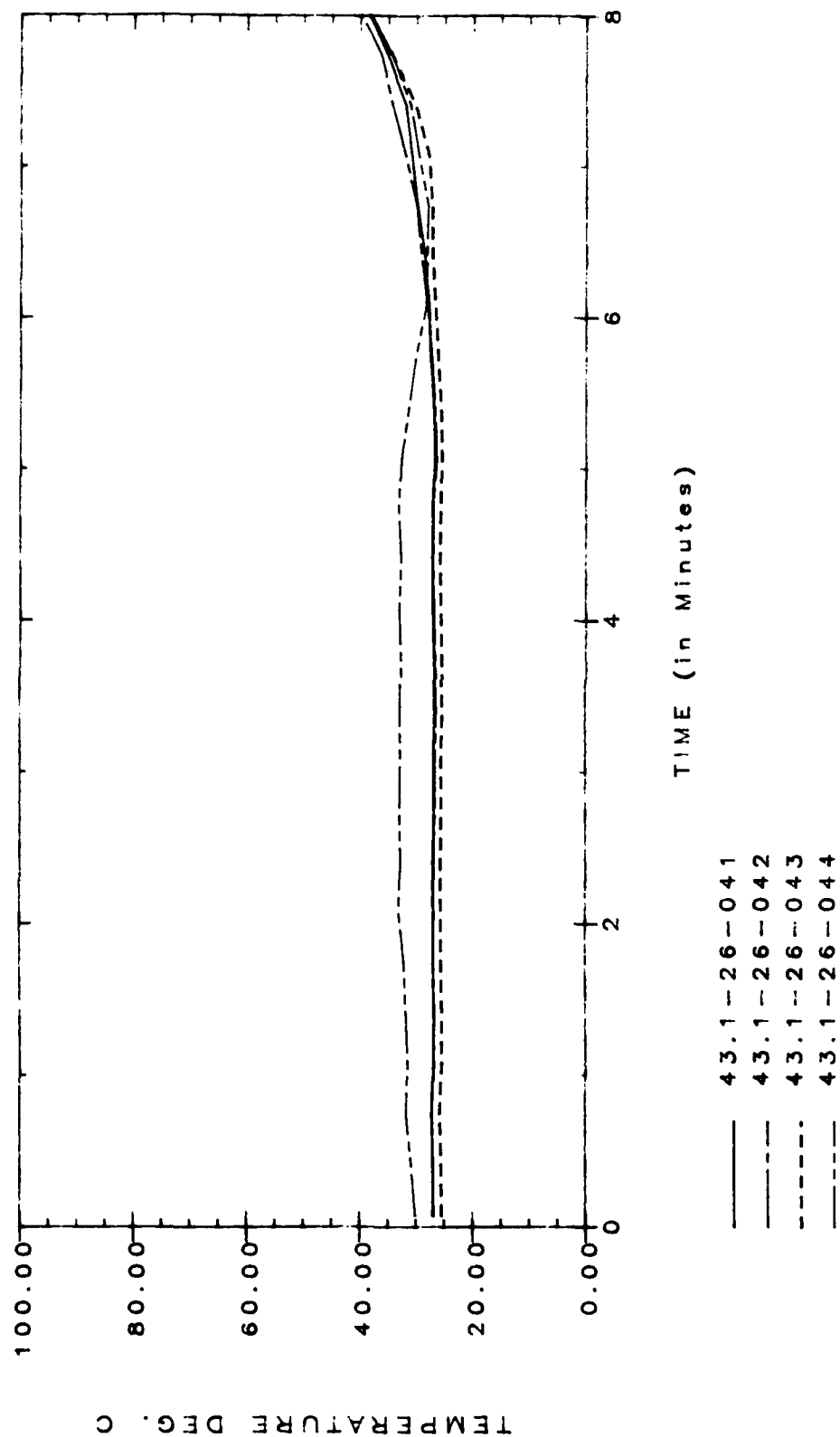
CAMERA LOCATION: 03 DECK

00:05:12 CENTER TANK FAILED (BOTTOM)
00:11:00 TOP OF CENTER TANK GONE
00:18:00 OUTER TANK TOP COLLAPSED

CAMERA LOCATION: 04 DECK

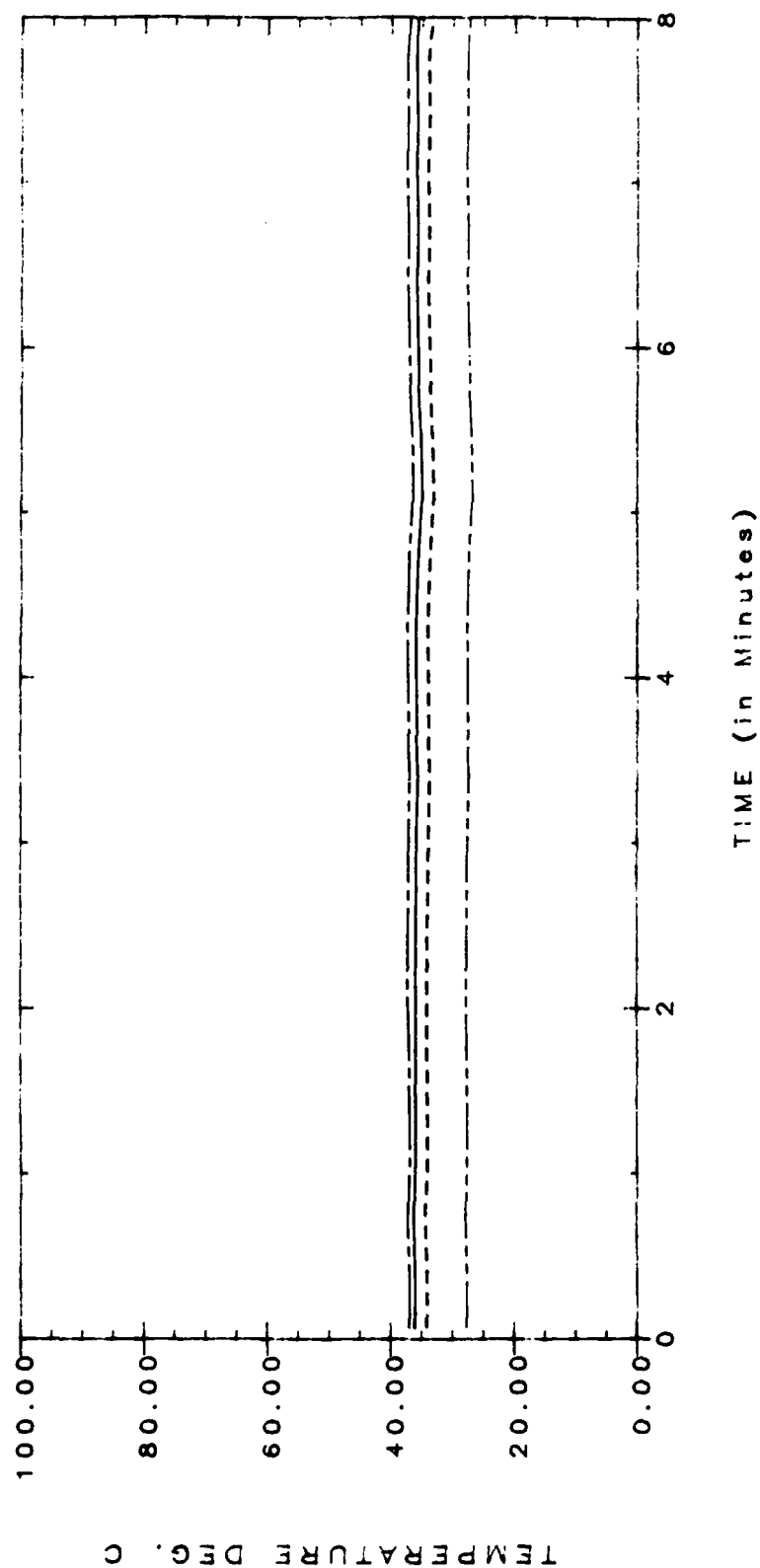
00:05:10 CENTER TANK FAILED (BOTTOM)
00:11:00 TOP OF CENTER TANK GONE
00:18:00 TOP OF OUTER TANK COLLAPSED

TANK TESTS



TIME/TEMPERATURE DATA

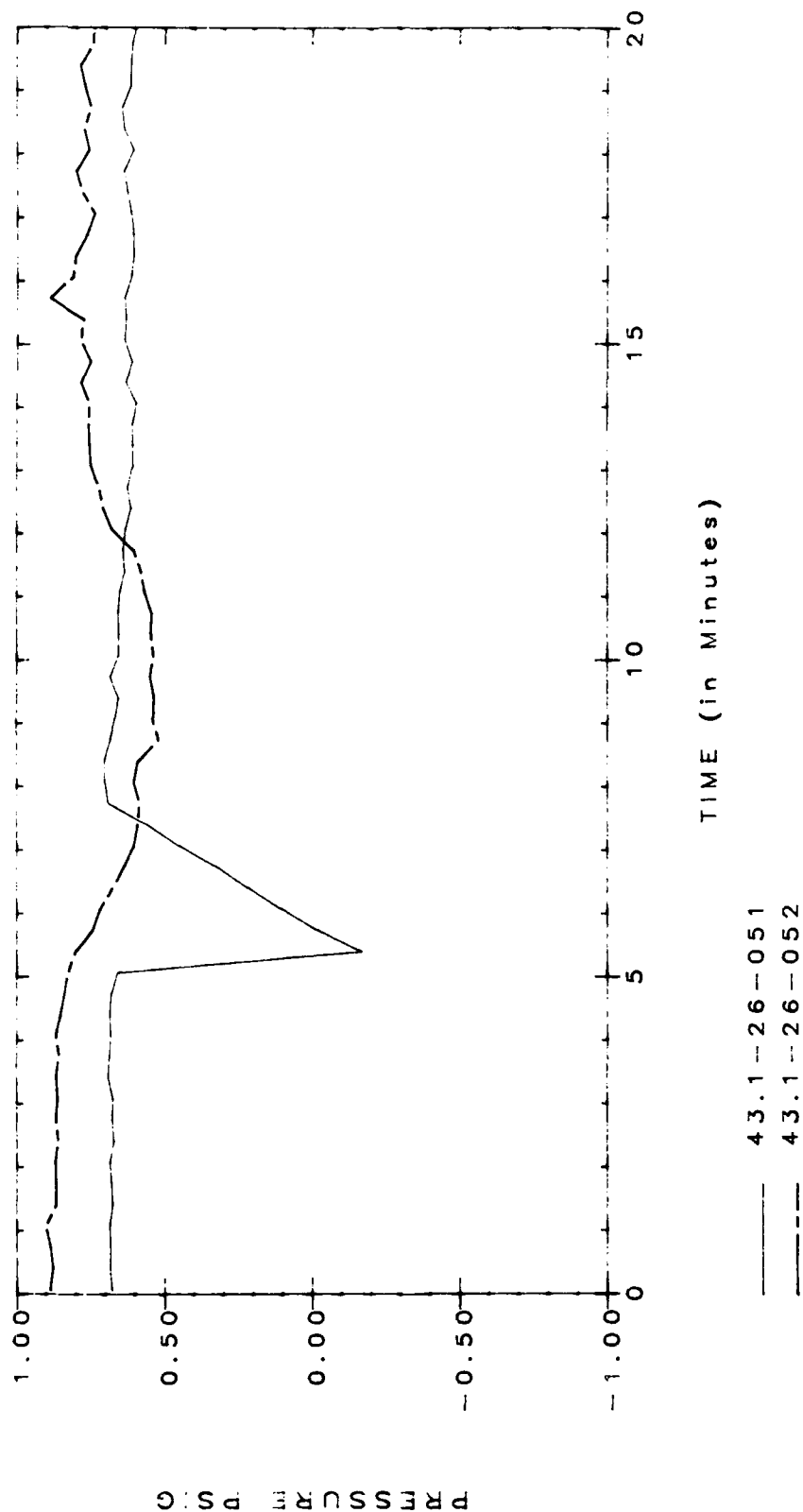
TANK TESTS



— 43.1-26-045
 - - - 43.1-26-046
 - - - 43.1-26-047
 - . - 43.1-26-048

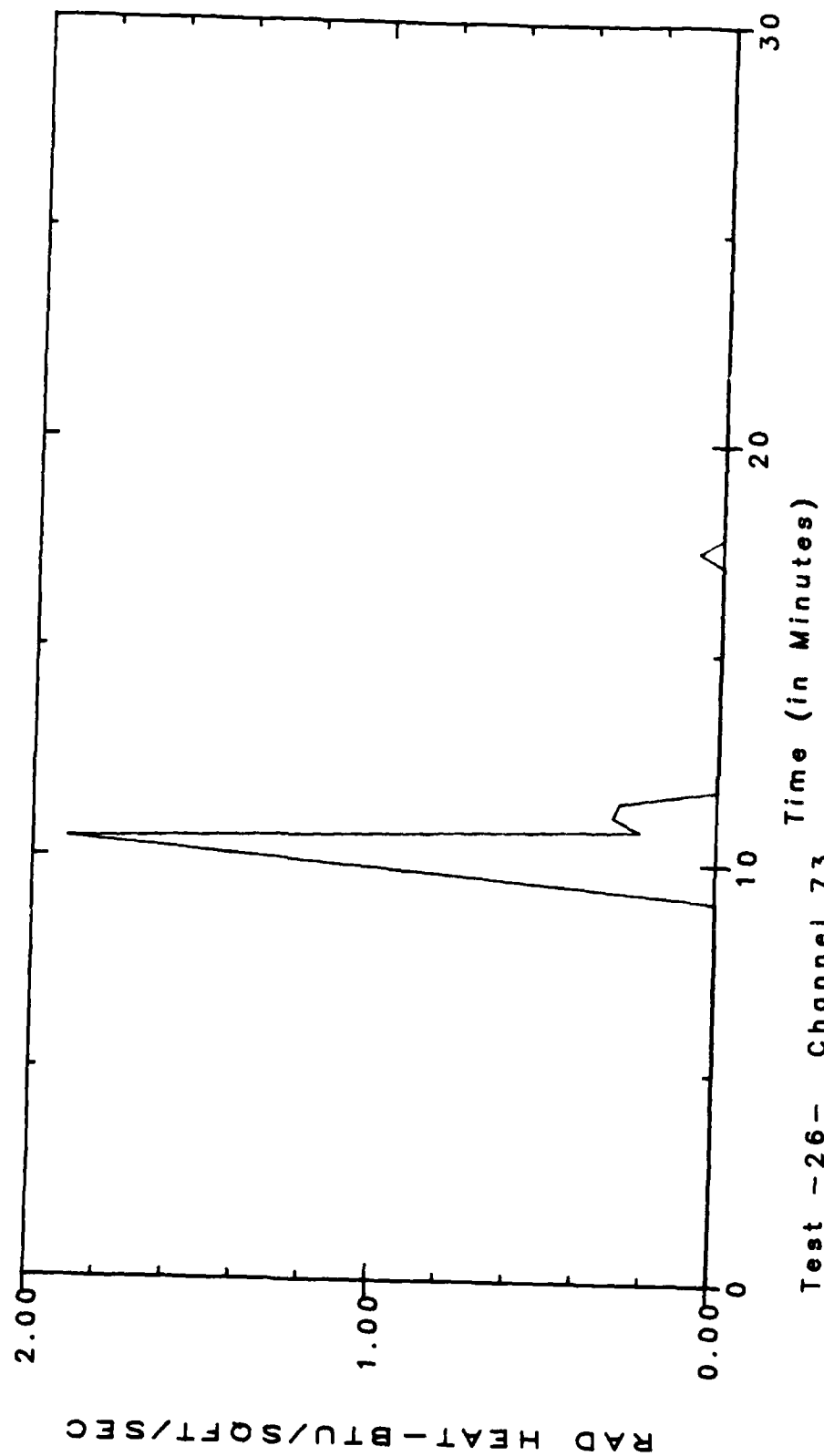
TIME/TEMPERATURE DATA

TANK TESTS



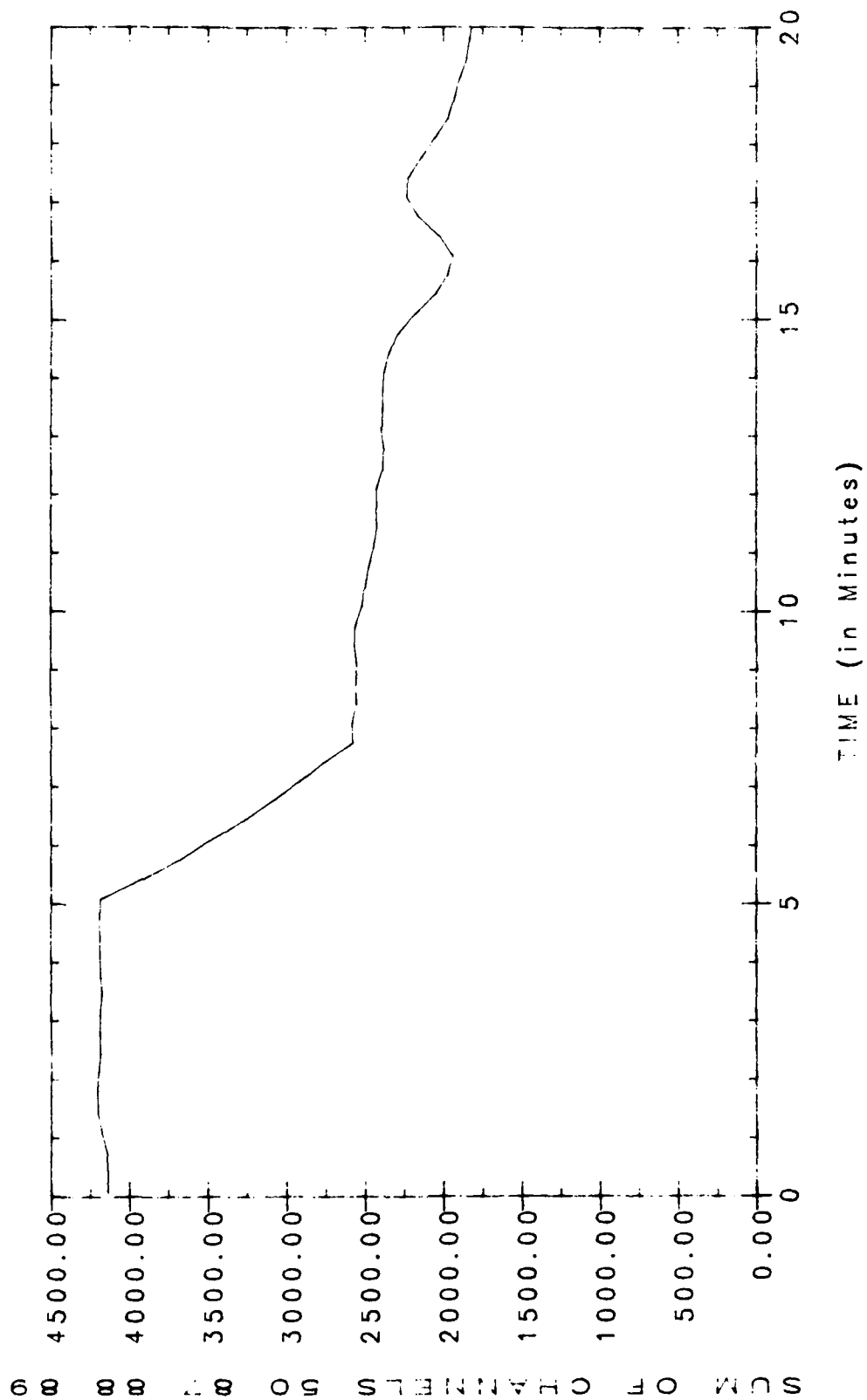
IN-TANK PRESSURE DATA

TANK TESTS



HEAT FLUX DATA
RADIANT HEAT

TANK TESTS



43.1-26-086

WEIGHT LOSS DATA
TEST TANK

TEST # 27

TYPE OF TANK: 2 POLYETHYLENE TANKS
TANK CONTENTS: #2 DIESEL 300 GALLONS, H2O 500 GALLONS OUTER
TANK

PAN FIRE SIZE: 4 SQ. FT.

DATE OF TEST: 8 SEPTEMBER 1986

CAMERA LOCATION: MAINDECK

OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:08:42 TOP OF INBOARD (OUTER) TANK BULGES
00:08:53 TANK FAILS? (SMOKE)
00:14:30 TOP OF OUTBOARD TANK GONE
00:14:46 EXTINGUISHMENT BEGINS

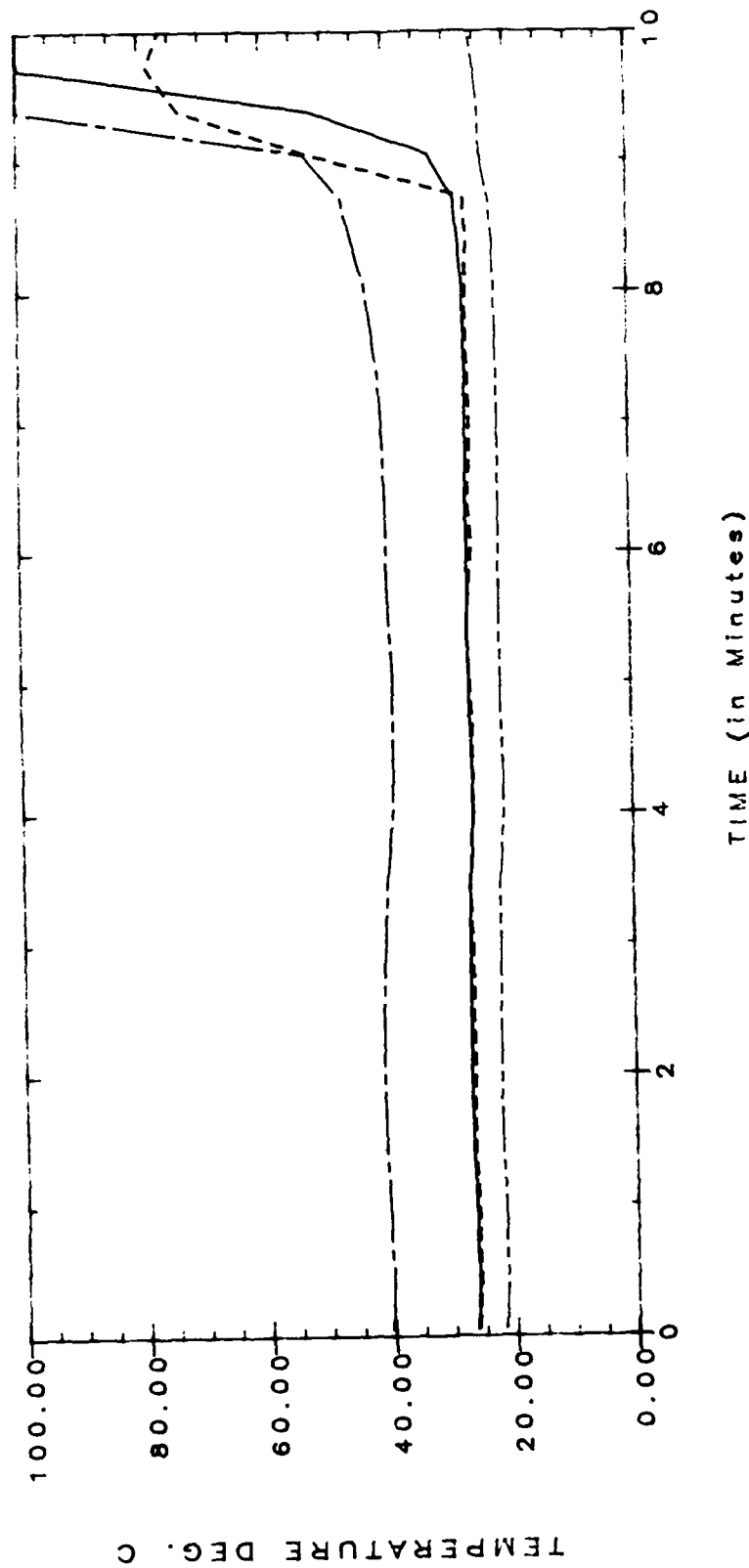
CAMERA LOCATION: 03 DECK

FLAMES AND SPRAY OBSCURE TANKS THROUGH MOST OF TEST
00:08:10 TANK FAILED (INBOARD)
00:14:30 EXTINGUISHMENT BEGINS
00:15:00 FIRE UNDER CONTROL

CAMERA LOCATION: 04 DECK

00:02:12 SMOKE SHOWING
00:08:10 TANK FAILS
00:14:26 EXTINGUISHMENT BEGINS
00:15:00 FIRE UNDER CONTROL

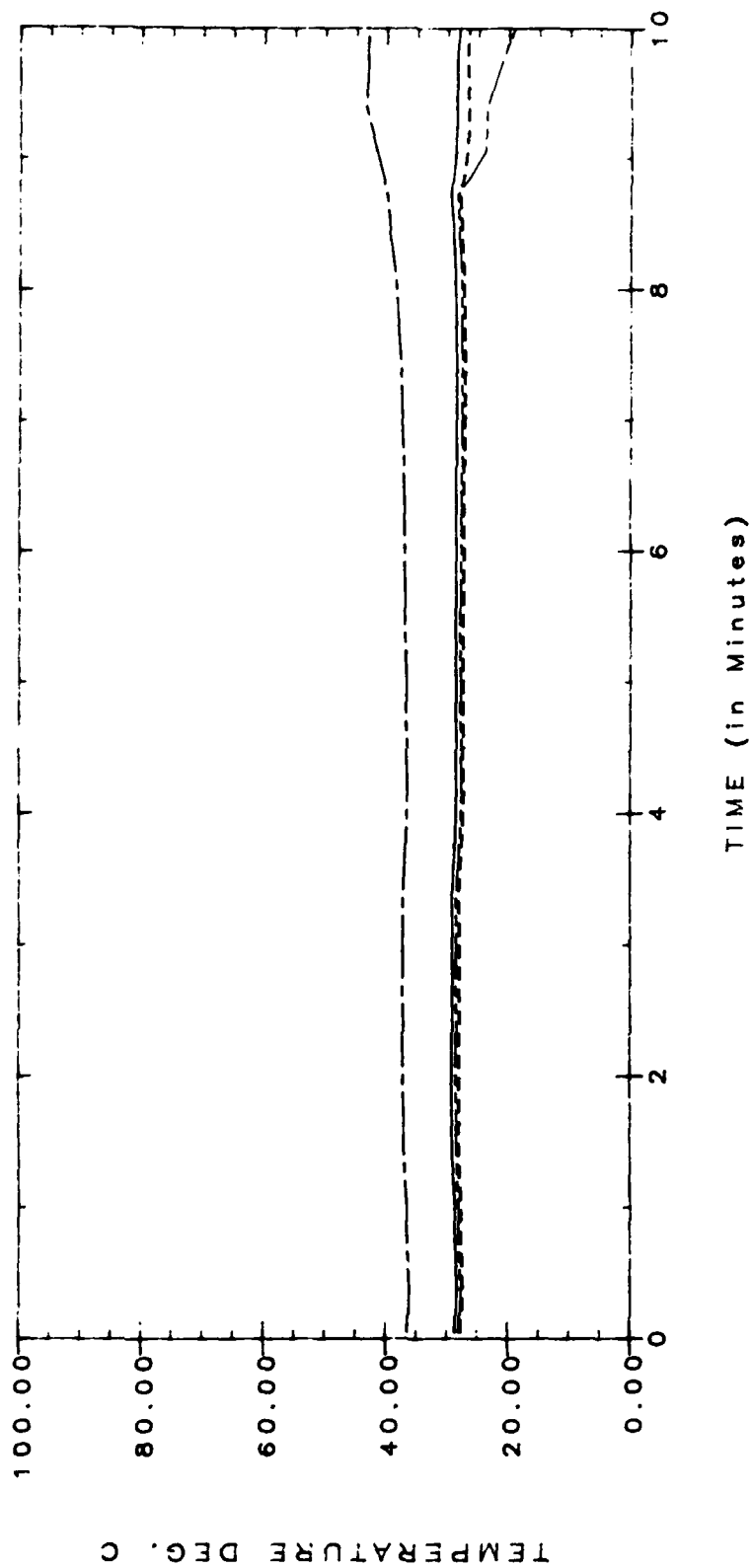
TANK TESTS



- 43.1-27-041
- 43.1-27-042
- 43.1-27-043
- 43.1-27-044

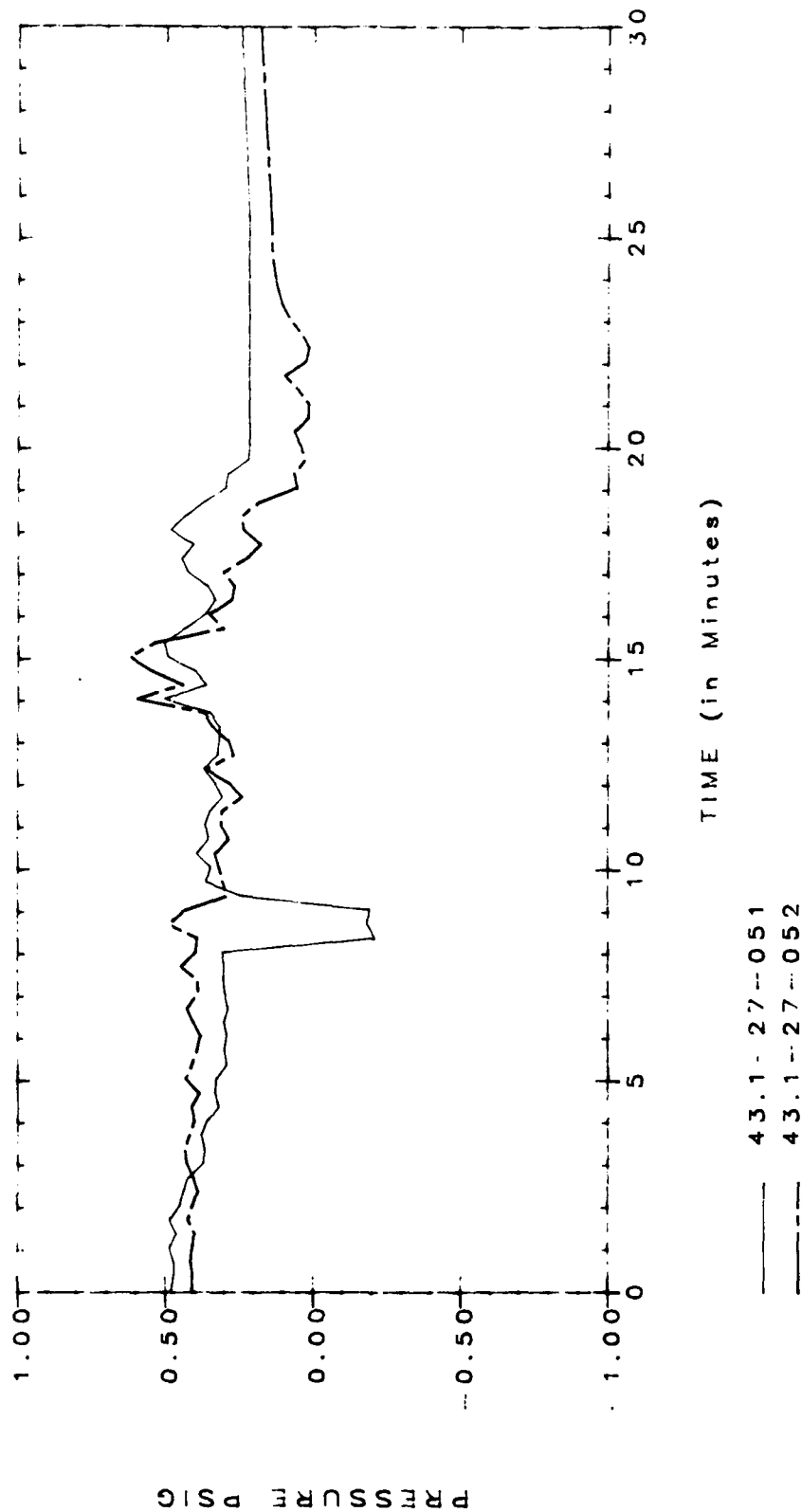
TIME/TEMPERATURE DATA

TANK TESTS



TIME/TEMPERATURE DATA

TANK TESTS

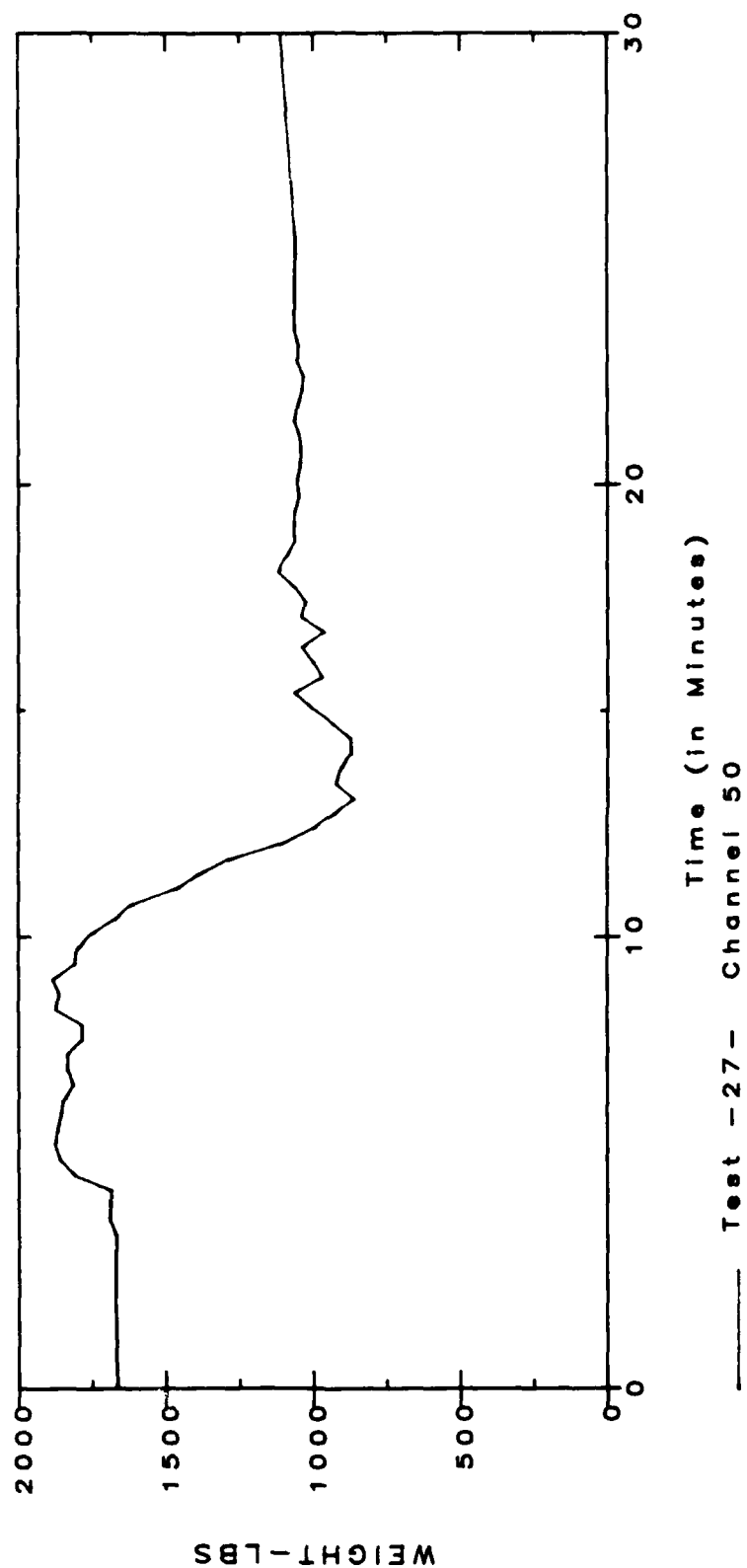


TIME (in Minutes)

43.1-27-051
43.1-27-052

IN-TANK PRESSURE DATA

TANK TESTS



WEIGHT LOSS DATA
TEST TANK

TEST # 29

TYPE OF TANK: 2 POLYETHYLENE TANKS
TANK CONTENTS: #2 FUEL
PAN FIRE SIZE: 4 SQ. FT.
DATE OF TEST: 2 JULY 1986

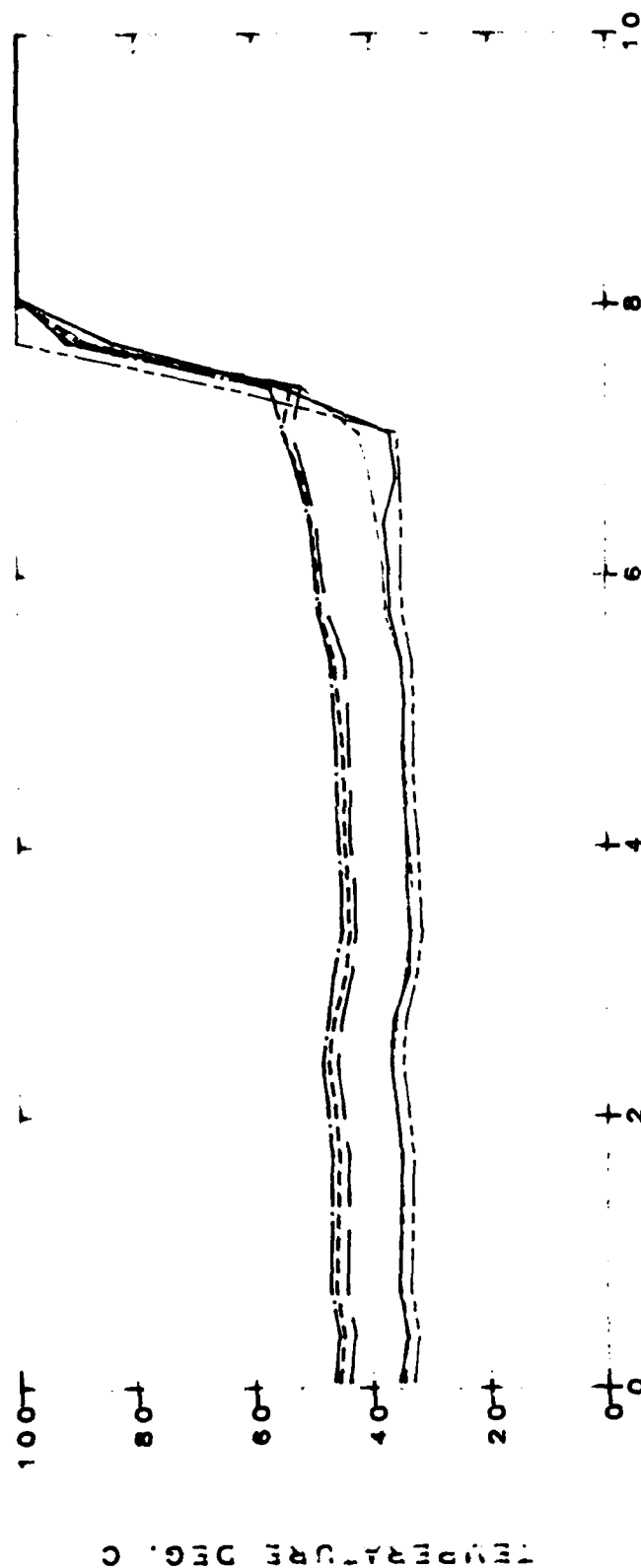
CAMERA LOCATION: MAINDECK
OBSERVATIONS: (TIME GIVEN IN HOURS, MINUTES, SECONDS)

00:04:51 INSIDE TANK FAILED
00:09:52 BOTH TANKS APPEAR TO HAVE FAILED
00:10:44 EXTINGUISHMENT BEGAN
00:18:30 REKINDLE

CAMERA LOCATION: 03 DECK

00:04:49 INSIDE TANK FAILED
00:09:18 OUTER TANK BLEW (VALVE?)
00:10:44 AFFF APPLICATION
00:18:33 REKINDLE
00:22:21 EXTINGUISHMENT

TANK TESTS

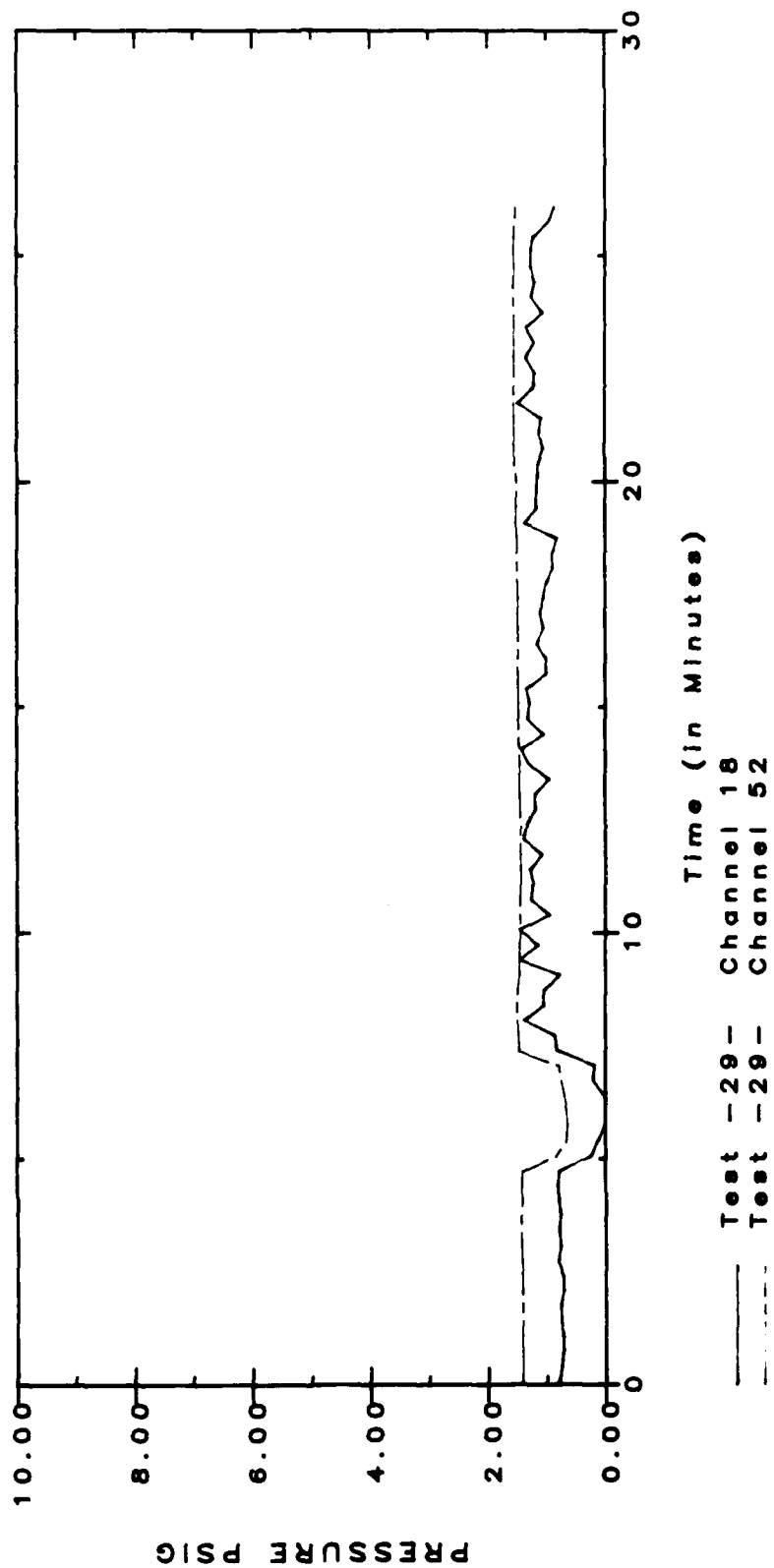


Time (in Minutes)

Test -29 -	Channel 46
Test -29 -	Channel 47
Test -29 -	Channel 48
Test -29 -	Channel 43
Test -29 -	Channel 41
Test -29 -	Channel 42

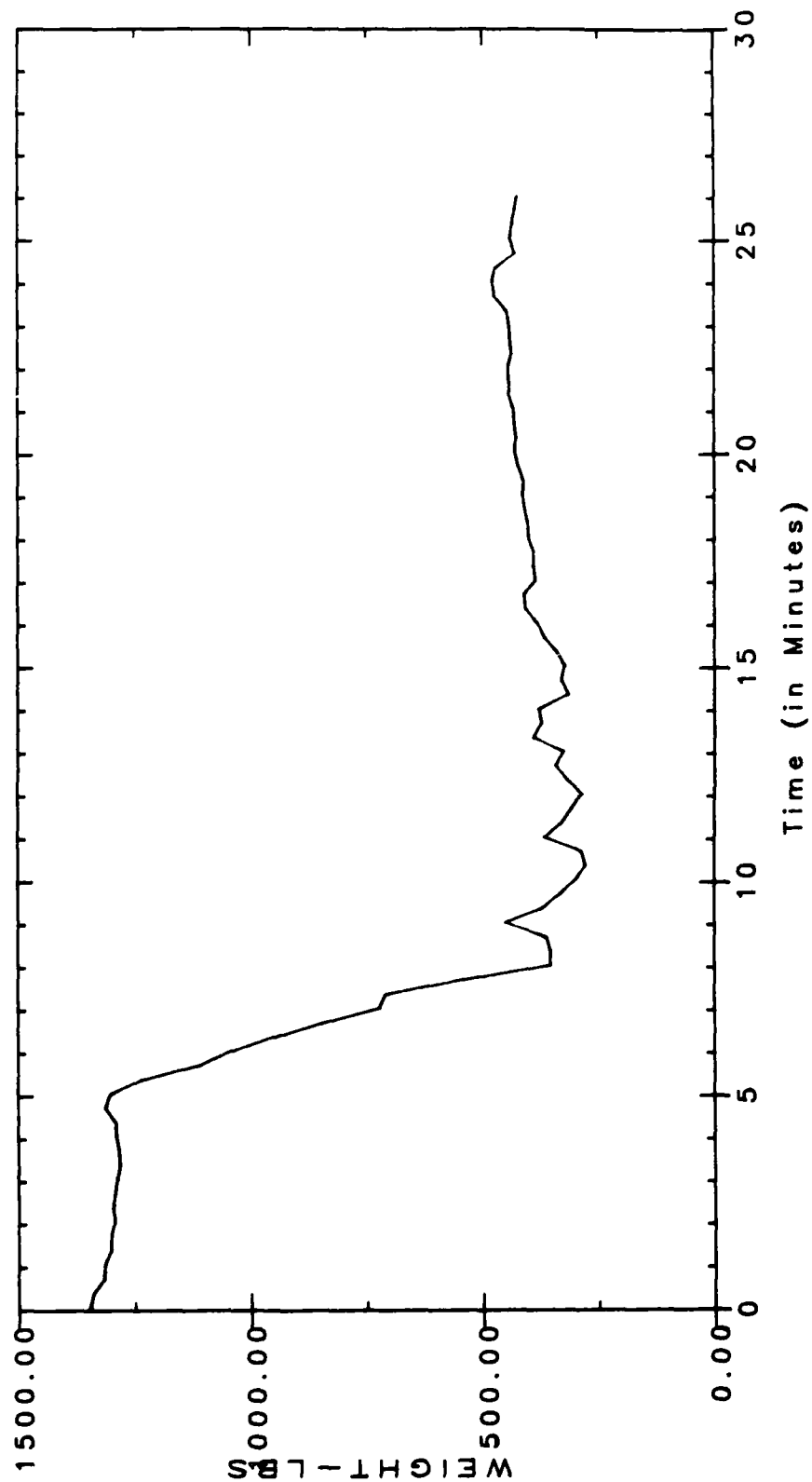
TIME/TEMPERATURE DATA

TANK TESTS



IN-TANK PRESSURE DATA

TANK TESTS



Test -29- Channel 50

WEIGHT LOSS DATA
TEST TANK

[BLANK]